VOL 4

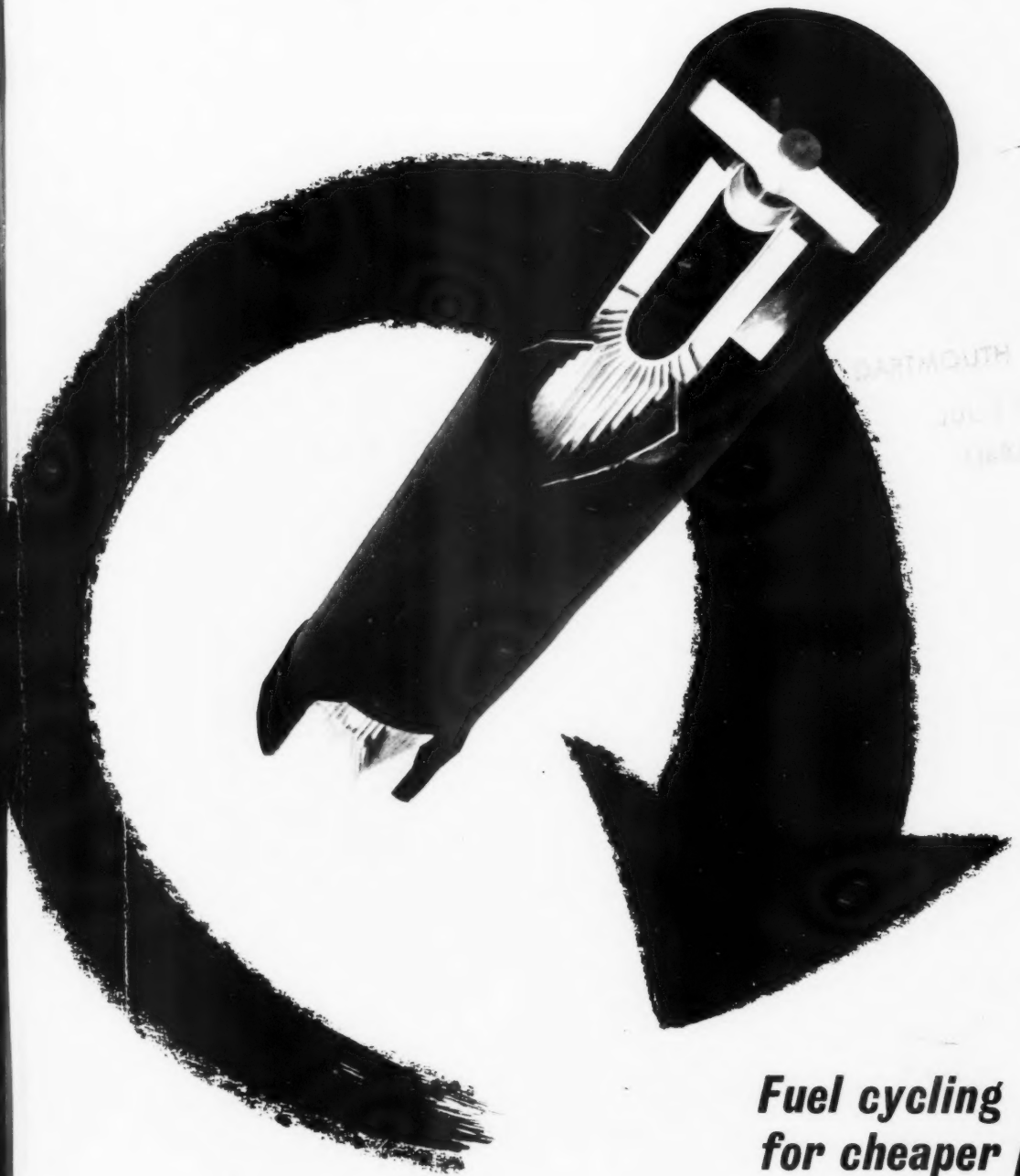
A ROWSE MUIR PUBLICATION

Phys. C

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

5412-27



Fuel cycling for cheaper power

. . . page 73

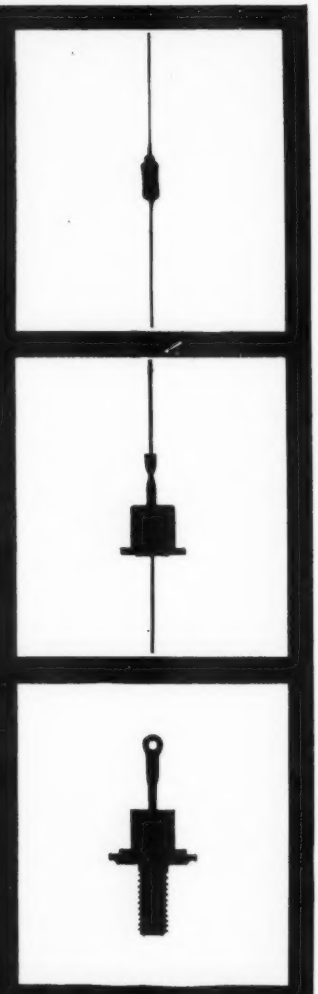
ly 1959 monthly 3/6

Pick No 1 on reply card for further details

SILICON RECTIFIERS

up to 600 Volts P.I.V.

3 amps



TEXAS SILICON RECTIFIERS offer excellent high temperature characteristics. For example the stud-mounted type gives an output of 3 amperes at 50 C and will still provide 1 ampere at 150 C with no change in the rated peak inverse voltage. The rugged, welded housing with glass-to-metal seal provides high resistance to shock and vibration. Listed in the table below are the characteristics of representative devices of each type.

Have you received your copy of the latest Texas Application Report "D.C. Power Supply Circuits using Silicon Rectifiers"? If not, or if you require fuller details of Texas Rectifiers, please write your name and address in the margin and return this advertisement to us.

	Symbol	1S001	1S005	1S111	1S115	1S401 1S401R	1S405 1S405R
MAXIMUM RATINGS							
Peak Inverse Voltage at −65 C to + 150 C	PIV	200V	600V	200V	600V	200V	600V
Average Rectified Forward Current at + 50 C	I_o	750mA	750mA	†400mA	†400mA	*3A	*3A
Average Rectified Forward Current at + 150 C	I_o	250mA	250 mA	150mA	150mA	*1A	*1A
Recurrent Peak Forward Current at + 50 C	i_f	† 2·5A	† 2·5A	† 1·25A	† 1·25A	*10A	*10A
Surge Current for 10 Milliseconds	I_{FS}	16A	16A	6A	6A	33A	33A
Operating Temperature, Ambient	T_A	−65 C to + 150 C					
SPECIFICATIONS							
Minimum Breakdown Voltage at + 150 C	V_z	240V	720V	240V	720V	240V	720V
Maximum Reverse Current at P.I.V. at + 25 C	I_{R_1}	10 mA	10μA	0·2 mA	0·2μA	10mA	10μA
Maximum Forward Voltage Drop at + 25 C	E_F	1·0V	1·0V	1·0V	1·0V	1·1V	1·1V
		(I_F 500mA)		(I_F 400mA)		(I_F 1Amp)	

* Rectifier mounted on 2" x 2" x $\frac{1}{16}$" aluminium Heat Sink † @ 25 C

TEXAS INSTRUMENTS LIMITED

TELEPHONE: BEDFORD 68051 DALLAS ROAD BEDFORD CABLES: TEXINLIM BEDFORD

April 18, 1960
B.T.

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

VOL 4 NO 39 JULY 1959

MANAGING DIRECTOR A. H. David Rowse, MA

EDITORIAL

EDITOR John Woodeson, BSC(ENG)
FEATURES EDITOR Patricia May, BSC
NEWS EDITOR Charles E. Steinke
EDITORIAL ASSISTANT Angela Funnell
PRODUCTION MANAGER Gerald Vane, BA (CANTAB)
PRODUCTION ASSISTANT Gerald Withers
CIRCULATION MANAGER George A. Crookeshank
CIRCULATION ASSISTANT E. A. Hutcheson

CONSULTANTS

INSTRUMENTATION Denis Taylor, PHD, MIEE, FIP
PHYSICS James F. Hill, BSC
METALLURGY Prof J. G. Ball, BSC, FIM
ISOTOPES A. G. Maddock, MA, PHD, DIC

ADVERTISEMENTS

DIRECTOR Harry T. Kane
ADVERTISEMENT MANAGER John Abram
SOUTHERN REPRESENTATIVE K. M. Towell
CLASSIFIED ADVERTISEMENTS John Deamer

MANCHESTER OFFICE
Barry Gibbs
18 Grangeway, Handforth, Cheshire
tel: Wilmslow 2600

NEWCASTLE OFFICE
Peter Doig
14 Neville Street, Newcastle 1
tel: Newcastle 20945

U.S. REPRESENTATIVE
Walter J. Masterson, Jr
Box 206, Essex, Conn. *tel:* South 7-1838

NUCLEAR POWER is published by Rowse Muir Publications Ltd, 3 Percy Street, London, W1, England. The entire contents are protected by copyright in Great Britain and all the countries signatory to the Bern Convention; nothing therefrom may be reproduced in any manner without the written permission of Rowse Muir Publications Limited. Nuclear Power must not, without the consent—in writing—from the publishers, be re-sold, lent, hired out or otherwise disposed of in a mutilated condition or in any unauthorized cover, by way of trade, or annexed to or as part of any other publication or advertising, literary or pictorial matter whatsoever. Special attention is called to the fact that your acceptance of this magazine with notice of the above terms constitutes a contract upon these terms between you and the person who sold it or supplied it. Subscriptions to publishers Rowse Muir Publications Ltd. Single copies UK 3/6, 5/6 overseas, 75c US and Canada. Per annum £2.2.0 UK, £3.3.0 overseas, $8.0 US and Canada plus 50s postage.

SPECIAL FEATURES

EUROPE'S MASTER PLAN

At the Stresa Conference in May, five hundred engineers and industrialists met to discuss how to achieve a programme of 8500 MW by 1965. Caldwell Davidson reports 69

FUEL CYCLE OPTIMIZATION IN POWER STATION DESIGN

Dr P.J. Grant of GEC shows how frequent on-load rearrangement of fuel may be an important factor in reducing power costs from second-round stations. 73

BURST SLUG DETECTION IN WATER-COOLED REACTORS

An adaptation of the Calder precipitation system, described here by Denis Aliaga-Kelly of Plessey Nucleonics, is to be installed in Dido and Pluto. 77

EVALUATION OF HEAT TRANSFER SURFACES IN BOILERS.

B.G. Ediss of the Nuclear Power Plant Co discusses the optimization problem between pumping losses and thermal efficiency. This month's instalment covers plain tubing 80

NUCLEAR TECHNOLOGY

INSTRUMENTATION :

International transistor convention 84

IRRADIATION :

Making some uncommon isotopes 85

MATERIALS :

Zircaloy - a new corrosion problem 86

PROGRESS IN INDUSTRY

SIMPLE ECONOMIC MANIPULATORS
Over the wall models now in C & V range 87

REGULAR FEATURES

Letters	61	New Product - Survey	88
Leader	63	Industrial Newsdesk	92
Worldview	65	Book Reviews	98
Cross-section *Gracchus*	83	Classified Advertisements	125

EMERGENCY ISSUE

As most home readers will know, there is at present a dispute in the British printing industry which has made the publication of a normal magazine impossible. However, by eliminating a certain amount of editorial and advertising we have been able to produce this special issue.

As publishers we are not parties to the dispute and we apologize to readers and advertisers for any inconvenience caused.

RM

ROWSE MUIR PUBLICATIONS LTD, 3 PERCY STREET, LONDON, W1, ENGLAND tel: Museum 8252

molysils

These special lubricants are combinations of Molybdenum Disulphide and Silicones, uniting the high lubricating potential of the former with the thermal and chemical resistance of the latter.

Molysils should be adopted where temperature conditions are too severe for petroleum based lubricants and silicones alone have not proved completely satisfactory.

They are employed for lubricating rubber or other petroleum sensitive materials for lubrication in the presence of most solvents and corrosive bodies and for advanced designs which must consider extremes or wide ranges of temperature.

Rocol

FIRST AND BEST IN MOLYBDENISED LUBRICATION

Write for FREE BOOK on Molybdenum Disulphide Lubrication to

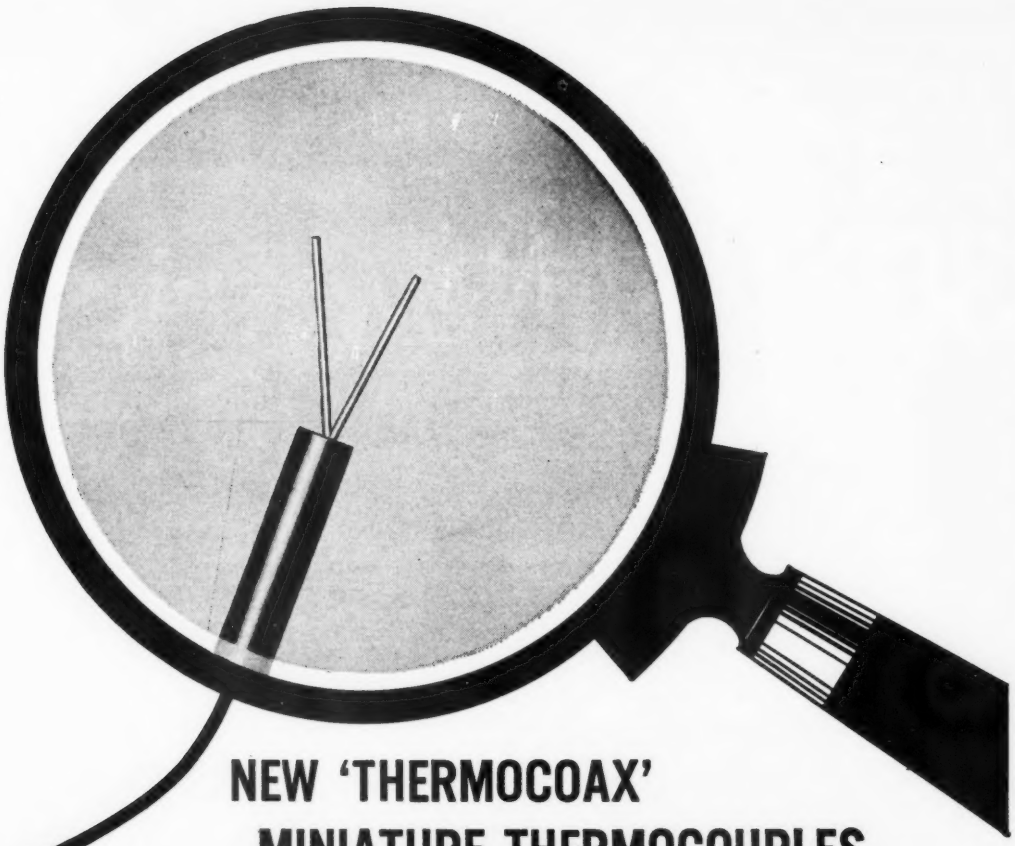
MOLYSIL 44
Grease for high temperature work.
Flash point–315°C. (600°F.)
Solidification point–minus 40°C. (minus 40°F.)

MOLYSIL 33
Grease for low temperature work.
Flash point–274°C. (525°F.)
Solidification point–minus 67°C. (minus 90°F.)

MOLYSIL NC.
Suspension of Molybdenum Disulphide in thickened Silicone fluid.
Flash point–274°C. (525°F.)
Sclidification point–minus 55°C. (minus 67°F.)

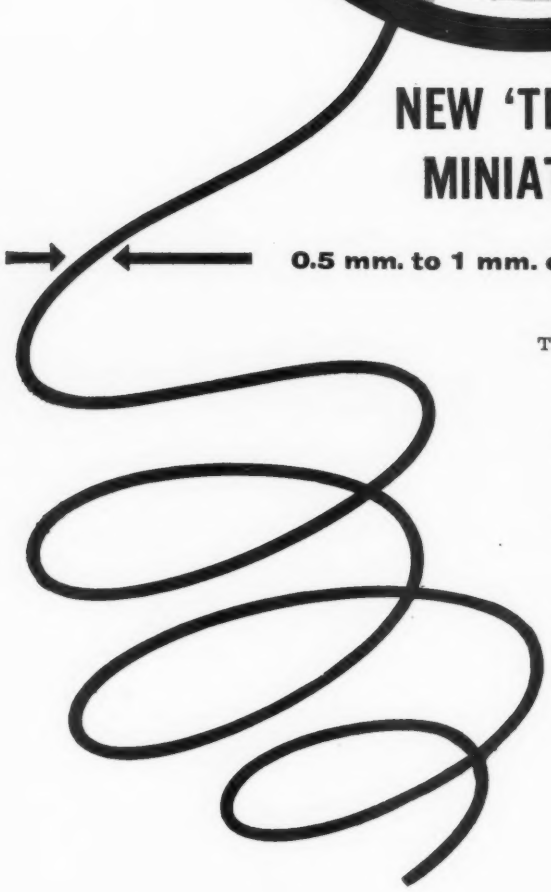
ROCOL LTD., Ibex Hse., Minories, London, EC3 Tel: ROYal 4372 ROCOL LTD., Rocol Hse., Swillington, Nr. Leeds. Tel: Garforth 2261/2.

rdh 1516



NEW 'THERMOCOAX' MINIATURE THERMOCOUPLES

0.5 mm. to 1 mm. outside diameter



The latest THERMOCOAX ceramic-packed miniature thermocouple wires have outside diameters of 0.5 mm. and 1 mm. and can be bent on a radius of 2 mm.

THERMOCOAX wire has great mechanical strength, especially against shock and high pressures, good stability at high temperatures and perfect insulation. Sharp bends can be made, the wire can be soldered or brazed to make gas-tight junctions, and the response time is very short. THERMOCOAX has a temperature range of 0-900°C. with an accuracy of within 2.8°C. up to 350°C. and 0.75% from 350°C. upwards. In nuclear applications it offers very small area for the capture of neutrons.

THERMOCOAX miniature thermocouple wires consist of an outer sheath of metal filled with powdered magnesium oxide and enclosing two cores of Chromel-Alumel† insulated from each other and from the sheath. The actual thermocouple is made by joining the two conductors together. THERMOCOAX is available in three types – 0.5 mm. and 1 mm. in diameter.*

** Marque deposee, produce of France † Trade mark Hoskins Mfg. Co.*

Full technical information supplied on request.

Sole Distributors in U.K.:

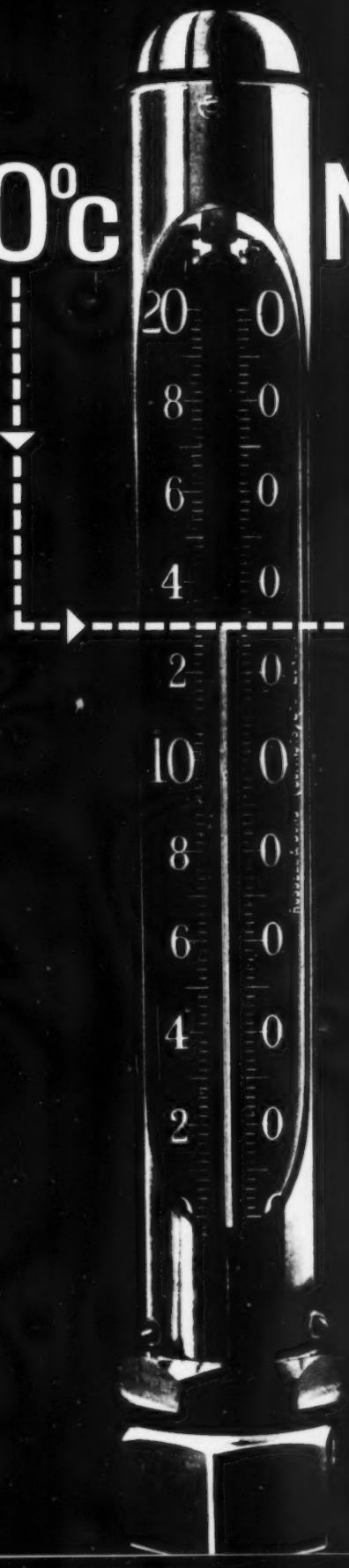
RESEARCH AND CONTROL INSTRUMENTS LTD

Instrument House, 207 King's Cross Road, London, W.C.1. Telephone: TERMINUS 8444

(RCL0427)

130°c

New triple life



AT THIS DANGER MARK

for Shell Alvania

For years now Shell Alvania greases have been a byword for stability in roller bearings. What is the secret? Lithium 12 hydroxy stearate, one of Shell's prized patents.

But stability is not enough. As new industrial techniques have been developed and new machines evolved, new problems have emerged with them and old problems have been intensified. Shell research teams at Thornton have made it their business to find the answers.

First problem was the *length of life of the grease charge* at the higher running temperatures of some modern machines. Could this life be lengthened? Shell scientists, through new Shell Alvania, have given an emphatic answer – at 130°C., the danger mark where most greases fail quickly through dynamic oxidation, Shell Alvania will live three times as long.

The second associated problem was the oxidation promoted by yellow metal cages. Could this be reduced? The answer, in Shell Alvania, is the virtual suppression of the effects of yellow metal.

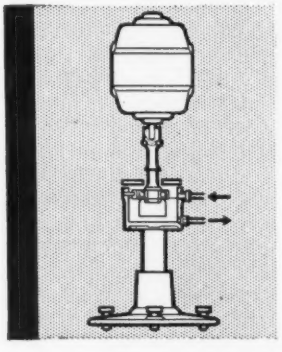
Problem three was corrosion caused by moisture. Could this be prevented? The answer was given in the Thornton Wet Bearing Rig Test*, where new Shell Alvania won an anti-corrosion rating of 10 out of 10.

New Shell Alvania greases were put on the market in March, 1957, and already, as proof of their success, tens of thousands of new electric motors leave British makers' works each week with Shell Alvania greases in their bearings.

What is the moral of the Shell Alvania story? That Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right grease for the job. If you and your organisation have any major lubrication problems, it will pay you to get in touch with your local distributor of Shell Industrial Lubricants.

The Research Story

*In the Thornton Wet Bearing Rig Test water was fed through a 20 mm. bore bearing with a special demountable plastic cage (to simplify inspection) charged with the grease under examination to a weighed quantity rotating at 3,000 r.p.m. The rate of supply of water was one gallon per minute, the water running to waste. After 5 hours' operation the bearing was removed and stored horizontally half immersed in water for three days. Anti-corrosion merit ratings were given at the end of the test. High-quality greases without special protectives showed an average rating of 3 out of 10, while new Shell Alvania rated 10 out of 10.



SHELL

ALVANIA GREASES

another proof of Shell leadership in lubrication

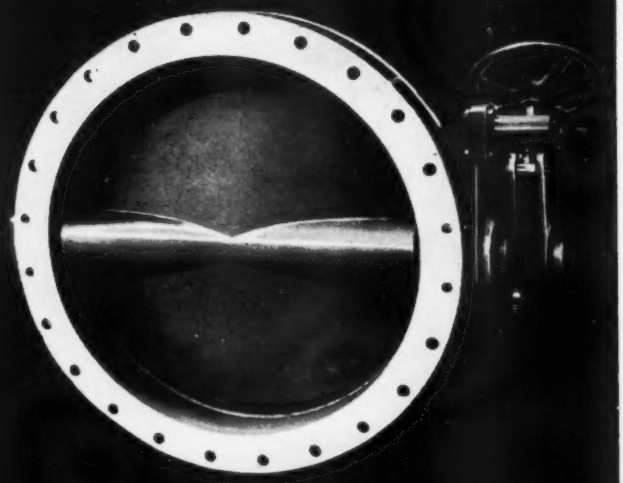
Tick **No 5** on reply card for further details

Boving

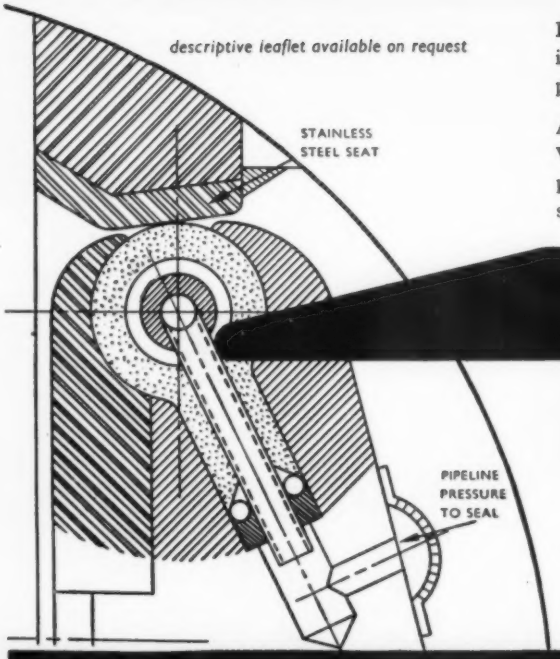
low pressure butterfly valves

- DROPTIGHT
- COMPACT
- LOW COST
- NON-JAMMING
- SEALING BY AUTOMATIC INFLATION

The reliability of this patented method of sealing has been proved in hydro-electric installations—after 25 years of service at heads up to 500 ft *the original seals were still intact.*



descriptive leaflet available on request



Low Pressure Butterfly Valves suitable for gases and fluids—including sea water. Vertical or horizontal mounting. Hand or power operated. Range 36 to 120 inches. Larger sizes to order.

Around the periphery of the valve blade is the expanding seal. With the valve closed the inside of the seal is subject to pipe-line pressure. This pressure balances external pressure and prevents seal from collapsing away from the seating.

Boving
& COMPANY LIMITED

WATER POWER ENGINEERS
56 KINGSWAY LONDON W.C.2

P1554

MOTORS for every industrial application. CONTROL GEAR for all motor drives.
TRACTION equipments for electric and diesel-electric locomotives and trains, and for trolley-buses. Railway Signal Equipment.
TRANSFORMERS SWITCHGEAR INSTRUMENTS METERS & RELAYS
TESTING EQUIPMENT ELECTRONIC CONTROL
WELDING EQUIPMENT AND ELECTRODES

WHATEVER THE INDUSTRY, you will find that the products of this company are contributing to the efficiency and smooth running of the electrical plant.

A few of the more important manufactures of the Metropolitan-Vickers organisation are listed in the panels, and the company will be glad to give you full details and descriptive literature dealing with the wide diversity of electrical equipment manufactured for every industrial and scientific application.

A.E.I. Turbine-Generator Division is supplying four 80 MW turbine-generators and the associated heat exchange equipment for Berkeley Nuclear Power Station.

M-V is responsible for the control rod mechanisms for Calder 'A' and 'B' and Chapelcross Power Stations of the U.K.A.E.A.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD TRAFFORD PARK MANCHESTER, 17

An A.E.I.. Company

LEADING ELECTRICAL PROGRESS

A/A612

Scintillators in 5 forms

Scintillators in five forms are now available from Nash and Thompson Ltd.

CRYSTALS

Anthracene, Stilbene, Diphenylacetylene, in discs and cylinders.

PLASTICS

N.11 and N.11-X-ray, high sensitivity, high transmission polyvinyl toluene based.

LIQUIDS

Ready made, sealed in glass containers to your specification, or as scintipaks.

SCINTIPAKS

Accurately mixed dry constituents sealed in polythene envelopes, ready for dissolving in a suitable solvent as required.

POWDERS

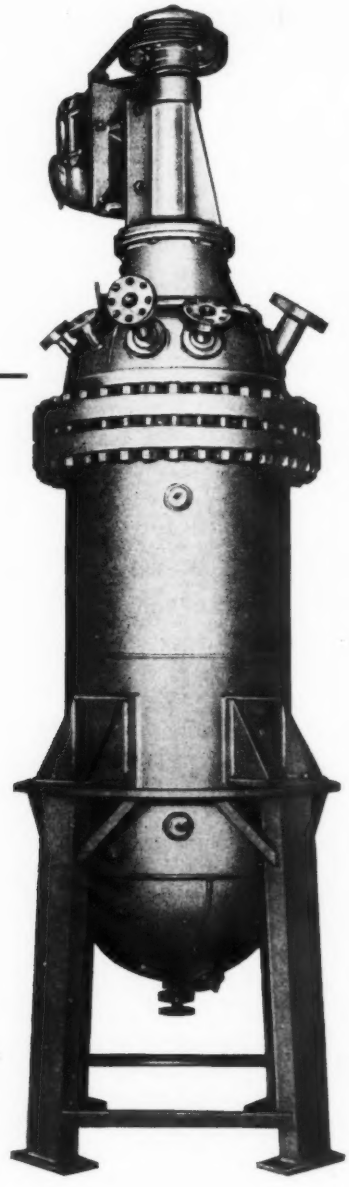
Scintillation purity chemicals for crystal growing experiments, and the manufacture of special scintillators.

Write or telephone for full information to

Nash and Thompson *LTD*

OAKCROFT ROAD · CHESSINGTON · SURREY · ENGLAND
ELMBRIDGE 5252

WHG/NT64



STAINLESS STEEL FABRICATIONS

UKAEA CLASS C APPROVED

- ★ Pressure Vessels of all classes.
- ★ Vessels for Storage and Transport.
- ★ Condensers and Heat-Exchangers.
- ★ Pipe work and Pipe fittings.
- ★ Laboratory Equipment and Holloware.
- ★ Ducting and other stainless steel sheet metal work.
- ★ X-ray weld inspection

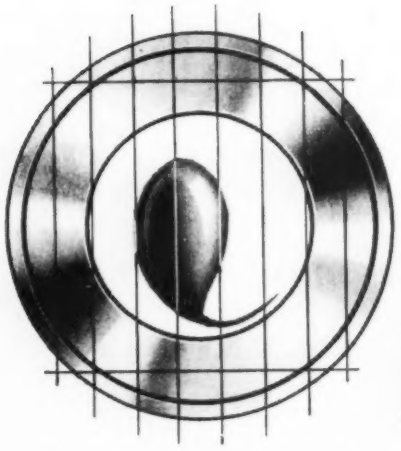
We are specialists in the manufacture of Stainless Steel Products, and consequently have gained an exceptional knowledge of this material, and the working of it. Our staff are skilled in design of equipment in this metal, and our workpeople in its manipulation. You could therefore, place your requirements in no better hands.

We have at our disposal a large machining and fabricating capacity, and are able to handle all types of fabrication up to 7 tons weight.

T
R F

THE TAYLOR RUSTLESS FITTINGS Co. Ltd.

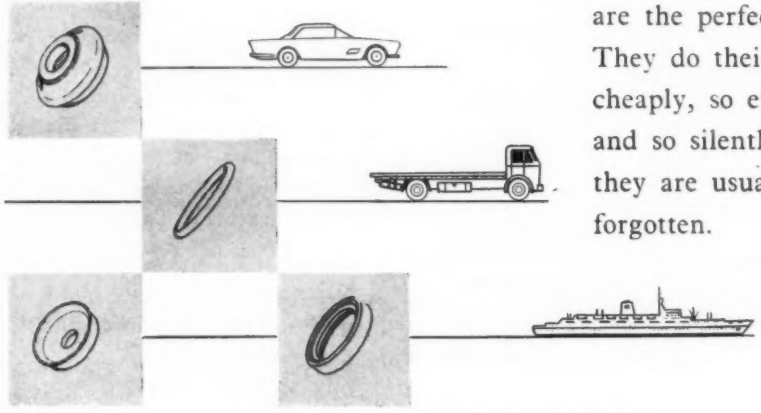
Head Office: Ring Rd., Lower Wortley, Leeds, 12. Tel: 638711. PBX
London Office: 14 Great Peter Street, London, S.W.1
Tel: Abbey 1575



Oil

is a difficult prisoner...

and it must be kept in solitary confinement too; no fraternisation with that insidious enemy dirt, either. SuPerfect Oil Seals are the perfect goalers. They do their job so cheaply, so efficiently, and so silently that they are usually completely forgotten.



SUPERFECT

SUPER OIL SEALS & GASKETS LTD.
FACTORY CENTRE, BIRMINGHAM, 30.

Manufacturers of 'SuPerfect' Hydraulic Packings and 'O' Rings; 'Romet' water pump seals and mechanical pump seals; 'Aeroquip' Flexible Hose with detachable re-usable fittings; 'Fidrac' mechanical rubber mouldings; 'Redcaps' Polythene Protective Caps and Plugs.

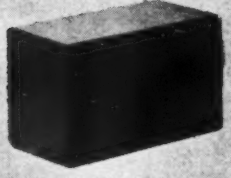
Fully Radiused Rectangular Cases

1470A 6″×4″×3″ £1 9 6

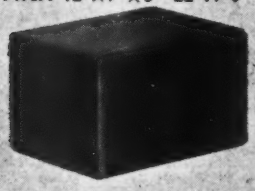
1470B 6″×4″×5″ £1 13 6

1480A 8″×5″×5″ £2 4 6

1480B 8″×5″×7″ £2 7 6



1490A 12″×7″×5″ £2 11 6

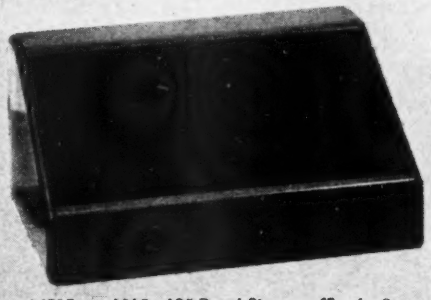


1490B 12″×7″×7″ £2 15 6

new small and miniature standard cases at really *LOW PRICES!*

15 new Imhof standard cases with panel sizes from 6″×4″ to 24″×10½″. Just look at these examples . . . compare the new low prices. Here's real value for money! Whatever the size —whatever the quantity—all these new cases are built to the same, robust specification and high finish as the existing Imhof Standard Range. Top quality and rock-bottom prices result from Imhofs streamlined methods and full tooling for large-scale production in Europe's most modern factory fully equipped for quality manufacture of cases, racks and consoles

Fully Radiused Sloping Panel Cases

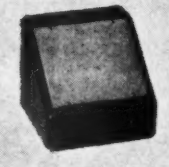


1450B 10½″×19″ Panel Size £5 4 0

1410C 7″ ×19″ Panel Size £3 12 8

1450A 10½″×12″ Panel Size £3 18 10

1410B 7″ ×12″ Panel Size £2 18 6



1410A 7″ × 6″ Panel Size £2 5 3

IMHOFS

These new cases have been designed as a result of the fast development in miniaturisation of electronics and electrical instruments. The cases are of two types: with sloping front panels, and rectangular cases with vertical front panels. Both types are available in standard duo-tone finishes. Imhofs have also produced a new type chassis incorporating fixing brackets especially for these new cases

7 days delivery–generous quantity discounts!

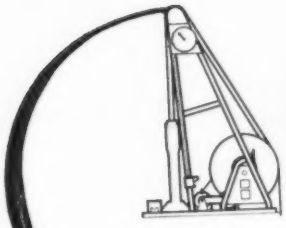
STOP PRESS! Now available, 9 new ultra-miniature cases—MINIBOXES—of two-piece construction. Sizes from 3″ ×1⅛″ ×2⅛″ to 17″ ×4″ ×5″. Prices from 6/9 to 25/-. Complete details on request

Alfred Imhof Ltd Dept N7 Ashley Works Cowley Mill Road Uxbridge Middx Uxbridge 6231

Export & London Showrooms: 112-116 New Oxford Street WC1 Museum 7878

IMHOFS AGENTS OVERSEAS

AUSTRALIA *Aladdin Industries (Pty) Ltd, Stanmore, N.S.W*
BELGIUM *Rogelec, Ghent*
CANADA *Measurement Engineering Ltd, Arnprior*
DENMARK *Tage Schouboe, Copenhagen N*
FINLAND *Oy Scienta Ab, Helsinki*
HOLLAND *J.Th. van Reijsen, Delft*
NEW ZEALAND *Imarex Ltd, Auckland C3*
NORWAY *Birger Christensen, Oslo*
SWEDEN *Elektronlund AB, Malmo C*
SWITZERLAND *Walter Blum, Zurich 2/39*
U.S.A. *Bud Radio Inc, Cleveland 3, Ohio*
BRIT. GUIANA *British Caribbean Agencies Ltd, Georgetown, Demerara*



PYE

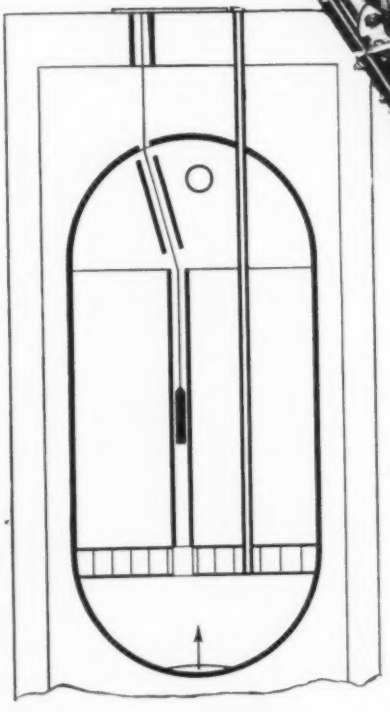
REACTOR INSPECTION
TELEVISION EQUIPMENT

REACTOR CAMERA

Television is a vital technique in the operation of gas-cooled reactors. The type of camera shown is in regular use at Calder Hall Nuclear Power Station, England; it carries its own lighting, and, in addition to visual inspection of the reactor interior, permits the removal of objects from the reactor using the special grab attachments. All the camera facilities are controlled remotely.

The camera functions satisfactorily with radiation dose rates greater than 10^5 Rads. per hour; cooling gas, carried to the camera by the supporting hose, allows operation with ambient temperature of 150°C.

Direct experience of such conditions over a number of years has enabled Pye to design cameras that will withstand high levels of nuclear radiation, temperature and pressure. Models can be supplied for use in water-cooled reactors. If you have any specialised television requirements, contact Pye Ltd., and avail yourself of their experience.



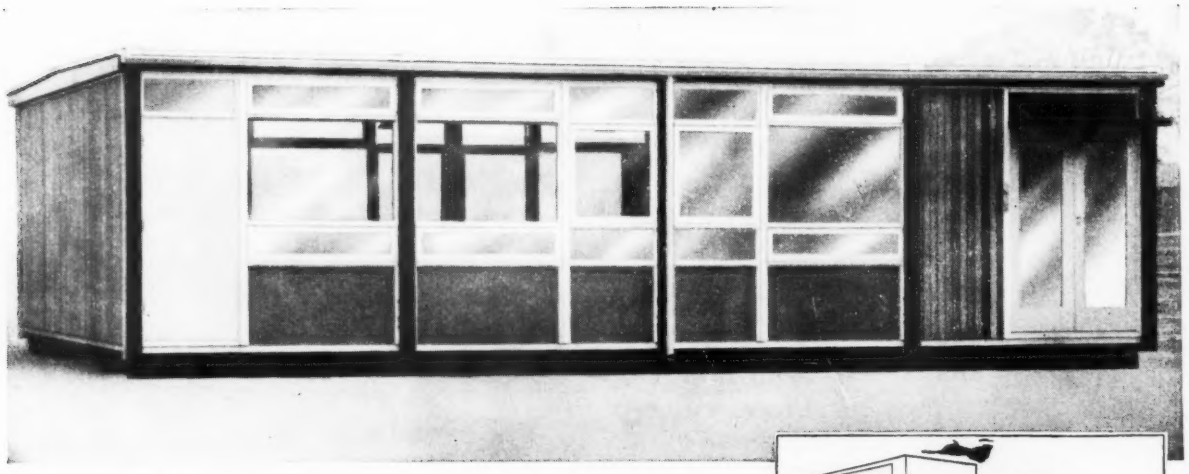
This console gives complete remote control of the camera. It carries the picture monitor and the control unit.

PYE LIMITED · ATOMICS DIVISION · CAMBRIDGE · ENGLAND

There's nothing to equal

SWIFTPLAN

FOR SPEED, ECONOMY AND FREEDOM IN DESIGN



SWIFTPLAN STAR FEATURES

UNIQUE FLEXIBILITY
in planning and design

UNINTERRUPTED FLAT CEILINGS

REMARKABLE EASE AND SPEED IN ERECTION
a block a day!

MINIMUM SITE COSTS

QUALITY MATERIALS
for strength and durability

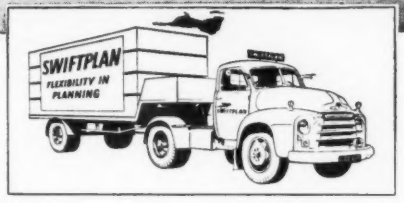
PRECISION BUILT—ENGINEER TESTED

ECONOMICAL TRANSPORT
(four units per vehicle)

100% RECOVERY VALUE

COMPLETE WITH DECORATIONS · FLOOR COVERINGS
LIGHT · HEATING · PLUMBING *as required*

AND THE SWIFTPLAN ALL-IN SERVICE
PLANNING · TRANSPORT · ERECTION · RE-SITING



Swiftplan Units (25 feet long by 8 feet wide) can be used in combination to form single, double or multispan buildings.

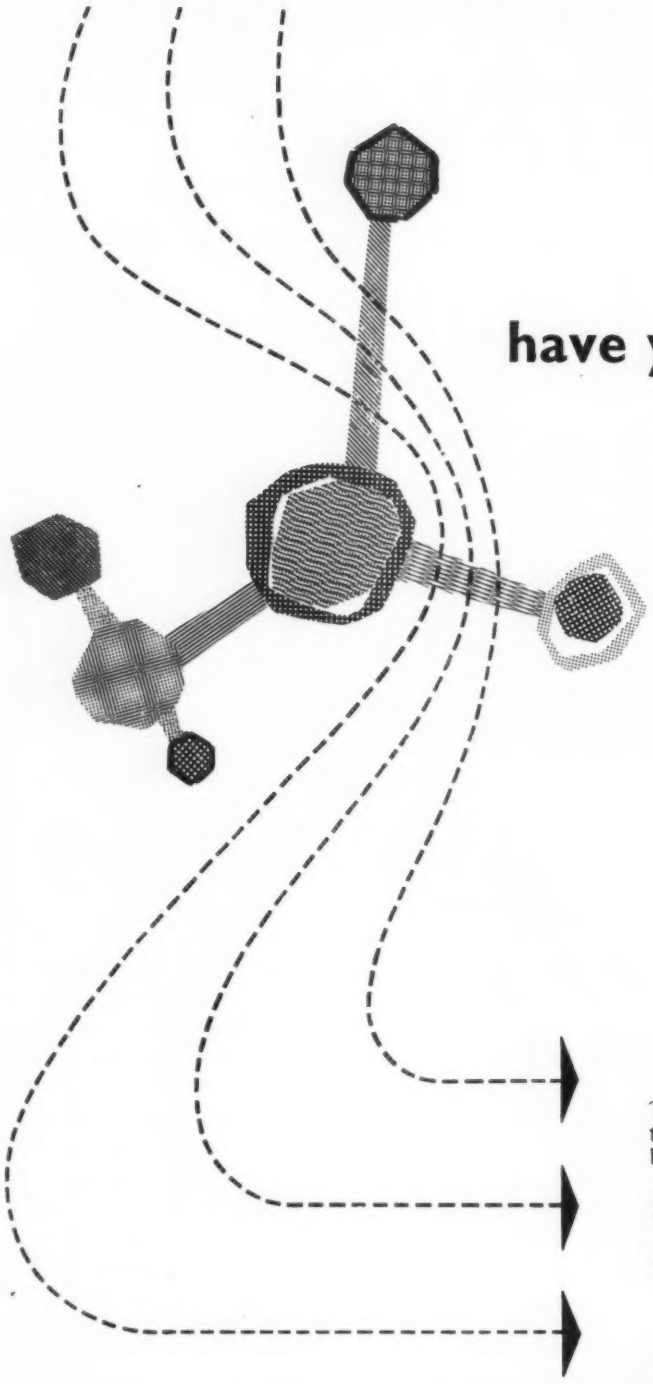
Here at last in Swiftplan you have all the advantages of a precision-built mobile building *plus* real freedom and flexibility in your planning and design! Doors, windows, etc., just where *you* want them—without extra charge! Far greater flexibility in positioning partitions, and a choice of alternative *heights* of building. (And—what is surely long overdue—uninterrupted *flat* ceilings!) Swiftplan opens the way to altogether new standards of efficient planning and aesthetic design. From every point of view—speed, quality, durability, economy—Swiftplan units excel. Write today for illustrated leaflet, and, if you have any accommodation problem on your hands, send us details and we will gladly advise you free and without obligation.

SWIFTPLAN
LIMITED

39 VICTORIA STREET · LONDON · S.W.1
Telephone . Abb . y 4393

MOBILE OFFICES · RAILWAY STATIONS · WORKSHOPS · STORES · CANTEENS · CAMPS · ABLUTIONS

Tick **No 13** on reply card for further details



have you a problem too?

The know-how needed to produce drop forgings to your requirements is dependent on experience backed by modern Technical resources.

If your needs are drop forgings* in special alloy, heat and creep-resisting steels or in special non-ferrous alloys, you'll solve many problems by consulting . .

FIRTH-DERIHON

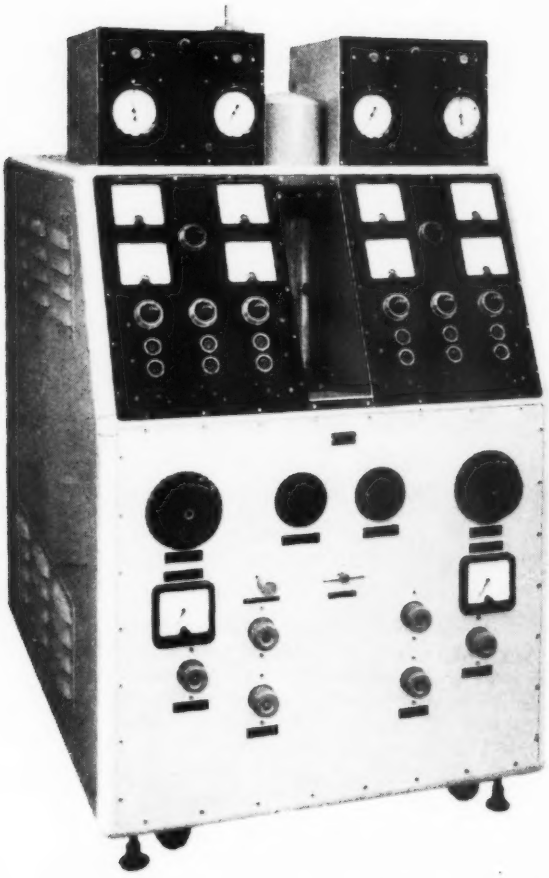
SHEFFIELD & DARLEY DALE

*** Drop Forgings are Stronger and Tougher**

A 16mm. Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request.

THE FIRTH-DERIHON STAMPINGS LIMITED, SHEFFIELD.

Do you require HIGH PURITY Argon?



For the removal of moisture, oxygen and nitrogen. For cleaning up the atmosphere in glove boxes. For welding or for any other application where the need arises to remove one or more of the above impurities.

THE MARK IV SELF-CIRCULATING GAS PURIFIER

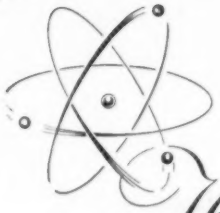
Supplied in single or in tandem units for long process work. Fully instrumented. Fully automatic

WESTERN DETAIL MANUFACTURERS LTD

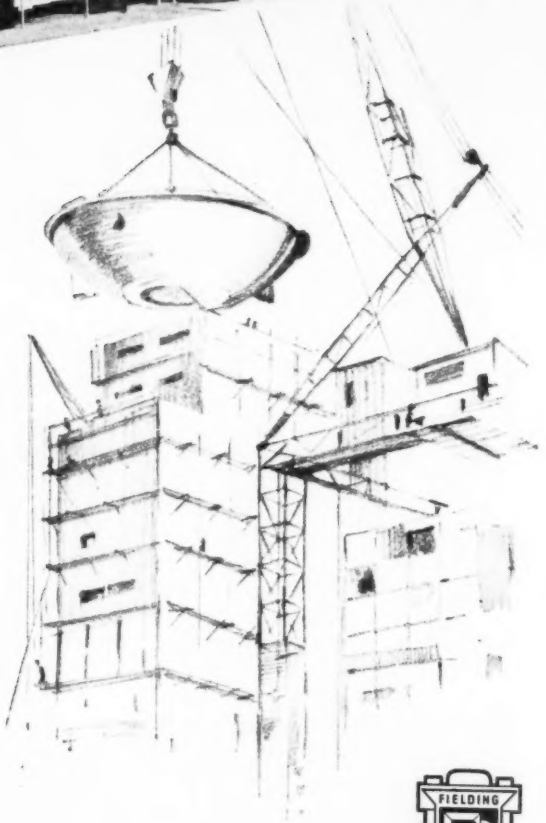
WESTERN WORKS, STAPLE HILL, BRISTOL.

Telephone 65-6141/2/3 Telegrams: Aries, Bristol Cables: Aries, Bristol, England

FIELDING
4,500 TON MULTI-RAM PLATE PRESS



Helping to solve another Pressing problem



The " FIELDING " 4,500 Tons, upstroking multi-ram plate press designed for the Whessoe Company Limited, Darlington, is assisting Britain's race in the field of nuclear power. Shaping the heavy steel plates, required for the shell of giant reactor pressure vessels is only one of the applications to which this press can be applied. It will accept the largest plates manufactured by the British Steel Industry today and still has a substantial margin of power to meet future developments.

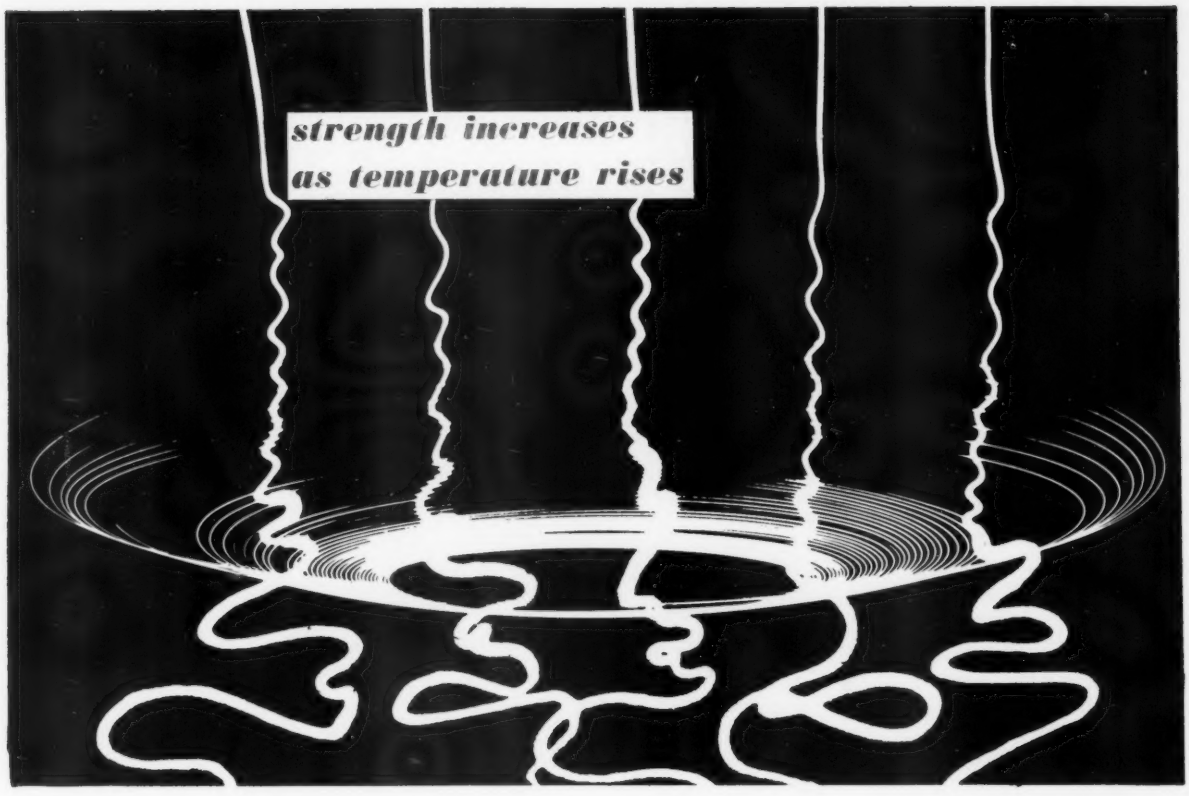
This press is only one of the large range of special and standard equipment manufactured by Fielding's; if you have a pressing problem your solution may lie with us. Our Technical Departments are always available to provide information and assistance.

FIELDING F & P PLATT

MEMBER OF THE HEENAN GROUP

FIELDING & PLATT LIMITED · ENGINEERS · GLOUCESTER · ENGLAND

K/FP.23.



UNION CARBIDE'S NUCLEAR GRAPHITE

for Moderators, Reflectors, Thermal Columns, Molds and Crucibles

Reactor components of UNION CARBIDE's nuclear graphite withstand tremendous heat—gaining in strength as temperature rises... gaining in strength when these components need that added strength.

For example, compression strength at 1600 deg. C. is 15% to 24% higher than at room temperature. And strength increases steadily all the way to the 2500 deg. level. Tensile strength at 450 deg. C. is approximately 3000 psi (211 kg/cm²). At 1350 deg. C. it measures 4000 psi (281 kg/cm²) and at 2500 deg. C. it reaches 5000 psi (352 kg/cm²). Here we have a 67% increase in tensile strength from 450 deg. C. to 2500 deg. C.—a temperature exceeding the melting point of most metals!

In addition, low neutron absorption cross section, easy machinability and reasonable cost—combine to make UNION CARBIDE's nuclear graphite foremost in many reactor programs. Great Britain's Calder Hall, for example, is equipped with nuclear graphite produced by one of our affiliated companies.

Whatever your needs—extreme purity, unusual shapes or sizes, high or low density, write to the leader in nuclear graphite, Union Carbide International Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, New York, U.S.A., Cable Address: UNICARBIDE, New York—or contact the company listed below which is nearest you:

ITALY
Elettrografite di Forno Allione, S.A.
Via Durini 28
Milan, Italy

FRANCE
Compagnie Industrielle Savoie Acheson
Boite Postale 78-08
Paris VIIIe, France

ENGLAND
British Acheson Electrodes Limited
Grange Mill Lane Wincobank
Sheffield, England

SWEDEN
Skandinaviska Grafitindustri A/B
P.O. Box 79
Trollhättan, Sweden

EUROPE
Union Carbide Europa, S.A.
40 rue du Rhone
Geneva, Switzerland

UNION CARBIDE

The term UNION CARBIDE is a trade mark of Union Carbide Corporation.

Tick **No 17** on reply card for further details

"But why can't they use my magnet?"

"Well, you see Johnny, it's because *your* sort of magnet can't be switched 'on and off'!"

"*Huh! I wouldn't like mine to do that!*"

"I know, but then you don't use yours to control water or gas and things."

"*Control water or gas? Seems stupid to me — why can't they use a tap like Mum does?*"

"Ah! But using a tap means that you rely on what's called the 'human element'. That's why these valves are fitted to do things automatically —without people being involved."

"*Mr. Stevens told me they make chocolates with them!*"

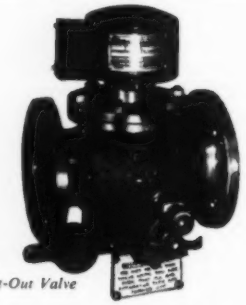
"That's right, but not exactly to *make* chocolates, to *help* make them. Mushrooms, too!"

"*Cor! I like mushrooms.*" *(Throwing away magnet)*
"*Can I have some for tea?*"

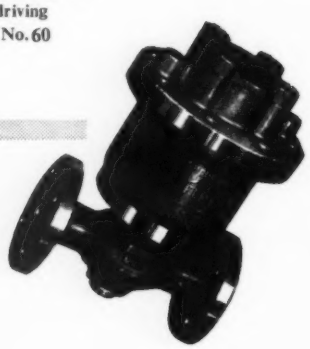
Seriously though, Magnetic Valves have earned an enviable reputation for absolutely reliable control of water, steam, coal-gas, oil, air, refrigerants and many other industrial liquids and gases. (Without using glands, stuffing boxes or driving shafts, either!) Full details are in our new Brochure No. 60 Why not write *NOW* for your copy?

MAGNETIC VALVES ARE USED EXTENSIVELY IN

AIR CONDITIONING	LAUNDRY PLANT
AUTOMATIC STOKERS	MACHINE TOOLS
BOILERS	NUCLEAR POWER PLANT
CENTRAL HEATING	OIL BURNERS
CRUCIBLE BAKING OVENS	REFRIGERATION
DYEING	STERILISING PLANT
GAS GENERATING PLANT	STEAM TURBINES
HYDRAULIC & PNEUMATIC-CYLINDER MECHANISMS	TINNING BATHS
HOT WATER SERVICES	VACUUM PUMPS
	VENTILATION



Magnetic Safety Cut-Out Valve



Magnetic Single-Beat Stop Valve with Flameproof Solenoid Enclosure

Magnetic 'PR' Type High Pressure Stop Valve

MVC **The Magnetic Valve Company Ltd**

7 KENDALL PLACE · BAKER STREET · LONDON W.1. Telephone: HUNter 1814

MV1

THE WORK OF YEARS

The transfer of heat from gas to steam in large quantities and at high pressures, and all the technical, mechanical and manufacturing problems associated with that work has been our special problem since the days of the small power station boiler.

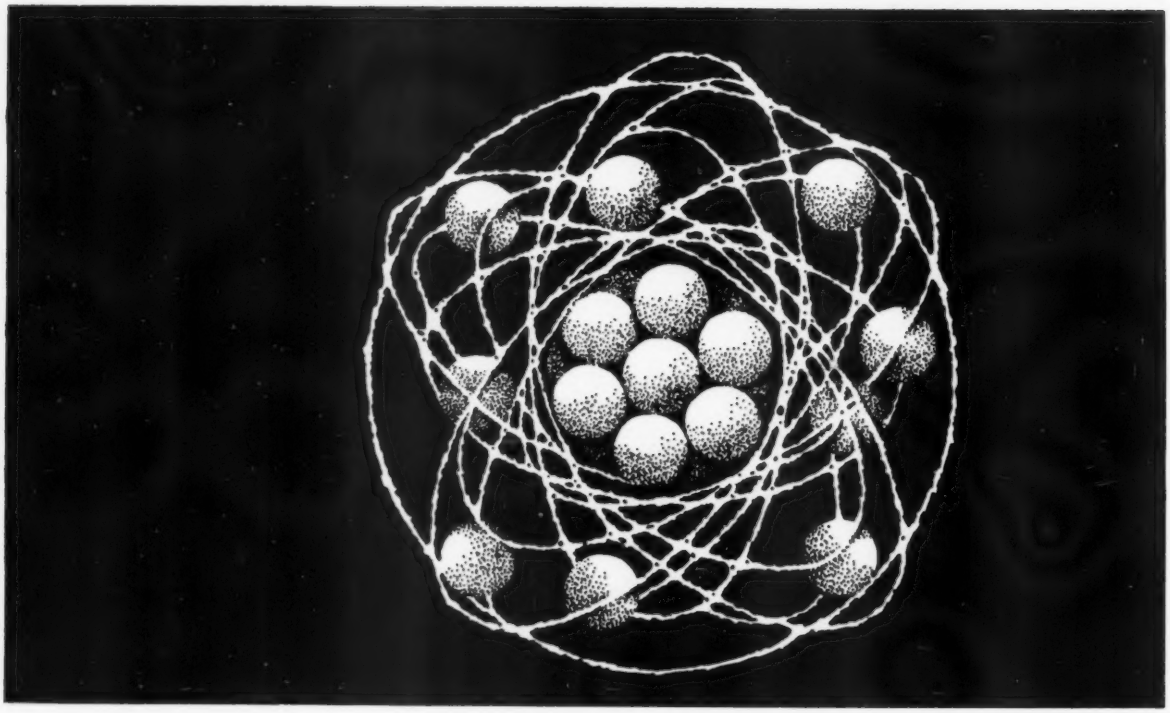
Our activities in the field of nuclear heat exchange is a natural outcome of this experience.

Flash welding an element for Hunterston.

THE SUPERHEATER CO. LTD.

97, TOTTENHAM COURT ROAD, LONDON W1

THE AUTHORITY ON SUPERHEATED STEAM



Main CO_2 Duct Isolating Valve for Nuclear Reactor Power Plants for working pressures of 10 kg/cm² and 400° C.

E R H A R D

ABSPERRKLAPPEN (Pat. throughout the world)

The design of the ERHARD-Absperrklappen is not limited to the aforementioned temperatures and pressures, and we are in a position to manufacture valves in order to meet the severest temperature and pressure conditions arising in nuclear reactor power plants.

External means are used in order to urge the disc sealing ring on to or away from the valve seat for closing or opening the valve. Operation can be effected according to requirements by hand, electric, pneumatic and hydraulic means.

For all information write to:

The Sole Agents for the United Kingdom

A. K. STARCK'S CO. LTD.

22, Chancery Lane London W.C.2

Telephone Holborn 2966 Cable: Akstar London

JOHANNES ERHARD H. WALDENMAIER ERBEN

Süddeutsche Armaturenfabrik Heidenheim an der Brenz Western-Germany

WHEN YOU ARE

thinking big

—THINK OF HARVEY

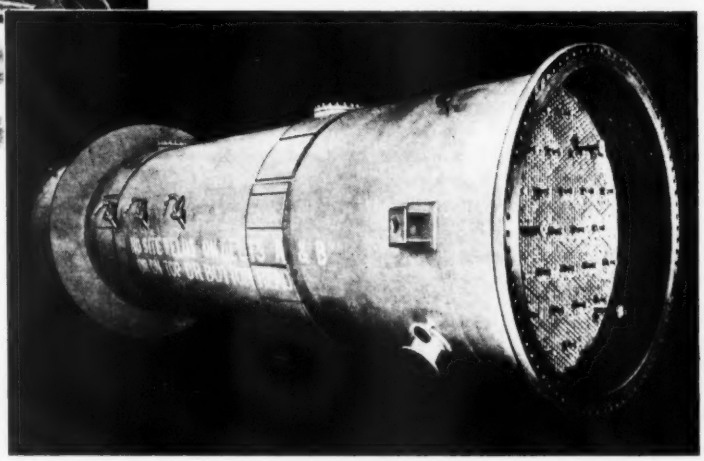
Harveys have the 'know-how', the space, the equipment and the skilled men to produce large fabricated assemblies with efficiency.

Assemblies up to 120 tons can be handled *in one piece*, and completed down to final machining. Full equipment is maintained for automatic welding, and stationary and portable X-ray units are supplemented by Radioisotopes for non-destructive testing.

Harvey engineers are always available to discuss your fabrication problems, and to advise how we can best help you.

Left: A mild steel jacketed Autoclave to Class 1 construction with electrically driven stirring gear.

Below: This Ethylene Oxide Reactor weighs 135 tons, is 9 ft. 6 ins. in diameter and contains over 15 miles of 1¾ in. dia. catalyst tube.



HARVEY FACILITIES AND PRODUCTS

CLASS 1 WELDED PRESSURE VESSELS TO LLOYD'S AND A.S.M.E. CODES · HEAT TREATMENT AND RADIOGRAPHY · DIE-PRESSED AND 'ROTARPREST' HEADS UP TO 15 FT. DIA. — *Larger sizes to specification* WELDED PRESSURE VESSELS AND FABRICATIONS IN ALL METALS · STEEL PLATE AND SHEET METALWORK · HEAVY MACHINING AND FITTING.

HARVEY

FOR *large* WELDED FABRICATIONS

G. A. HARVEY & CO. (LONDON) LTD., WOOLWICH ROAD, LONDON, S.E.7. GREenwich 3232 (22 lines)

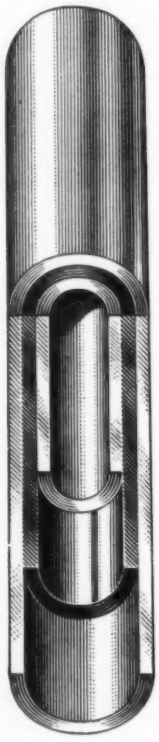
HC/HT/10

Some recent developments in manufacturing techniques and special applications of tubes in a variety of metals . . .

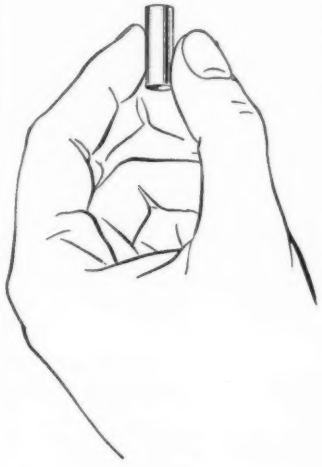
No. 3 OF A SERIES BY ACCLES & POLLOCK

This type of tube, made by a special process which ensures accurate bore dimensions with improved surface finish, is used in plant involving very high pressure work.

Triple composite tube: the mild steel tube is sheathed and lined with copper.



An oval tube in austenitic stainless steel, used in the electronic industry. The dimensions are .176″ major axis x .073″ minor axis x .006″ thick.



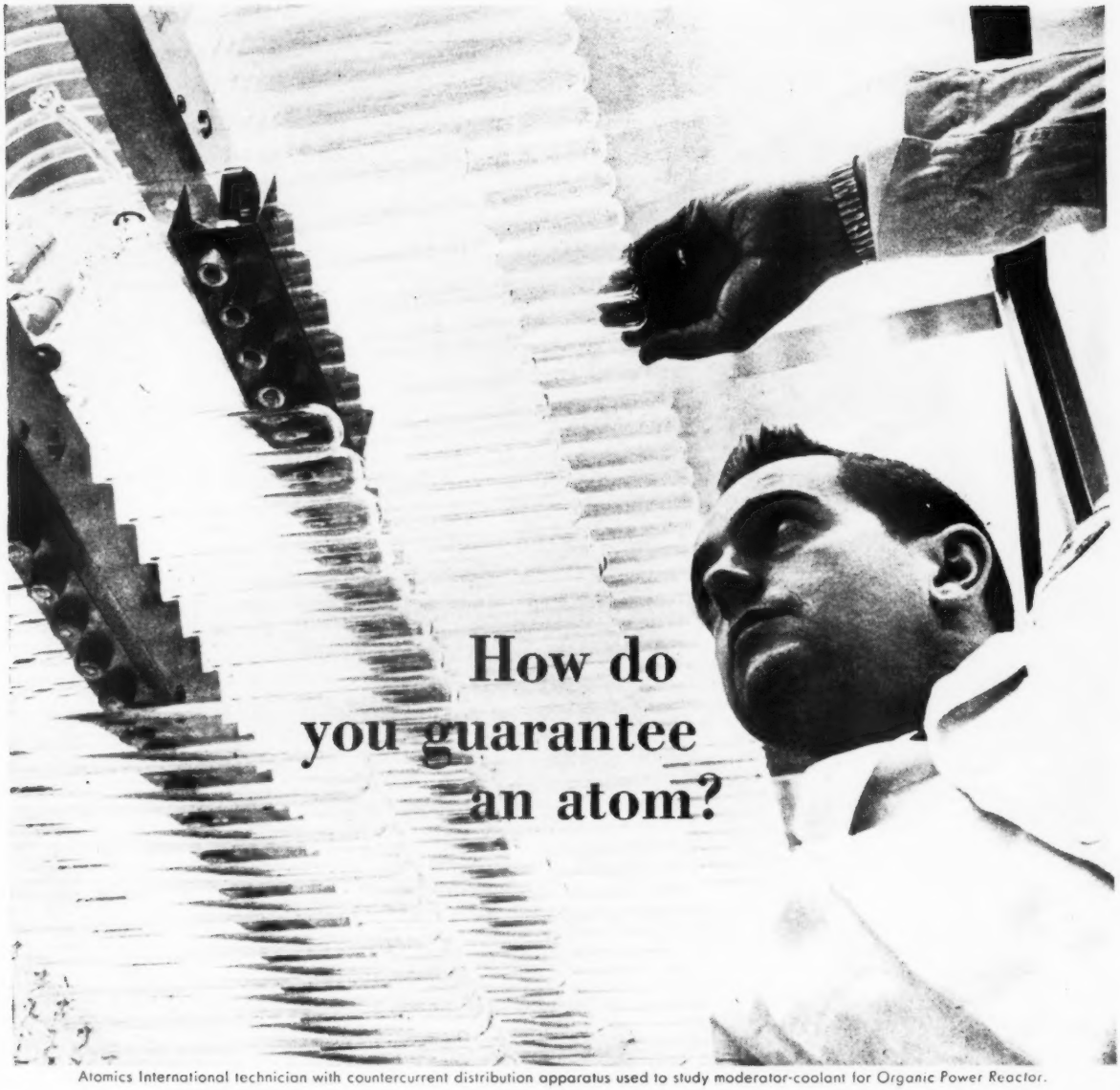
Designers have a habit of asking for the impossible, but in a surprising number of cases Accles & Pollock produce an answer that enables the production people to translate the concept on the drawing-board into a physical, functional form. Accles & Pollock welcome all such opportunities to co-operate in developing new applications in the form of tubes and tubular sections.

Accles & Pollock

Accles & Pollock Limited · Oldbury · Birmingham · A TI Company

Makers and manipulators of COLD DRAWN SEAMLESS and WELDED PRECISION TUBES in carbon and alloy steels, including stainless steel, and other metals

TSW/217



Atomics International technician with countercurrent distribution apparatus used to study moderator-coolant for Organic Power Reactor.

Begin with the knowledge of experienced scientists... conduct a seven-year research and development program ... collect a wealth of solid operating experience. Result: GUARANTEED PERFORMANCE of a nuclear power reactor, designed by Atomics International to help meet the world's power needs.

This is the ORGANIC POWER REACTOR—outgrowth of research and development on the organic system and operation of the Organic Moderated Reactor Experiment (OMRE) conducted by Atomics International for the U.S. Atomic Energy Commission.

Outstanding advantages of the ORGANIC POWER REACTOR: Low capital investment • Low cost operation • High inherent safety and flexibility • Reliability

resulting from

- Non-corrosive moderator coolant • Low pressure system
- Conventional, off-the-shelf components and materials
- Easy access during operation

Atomics International is ready to furnish complete ORGANIC REACTOR electric power plants, including fuel elements, in a wide range of power levels. An experienced field staff will assist with initial plant operation, personnel training and maintenance procedures.

For details contact: ATOMICS INTERNATIONAL, Canoga Park, California, U.S.A. Cable address: ATOMICS.

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN AVIATION, INC.

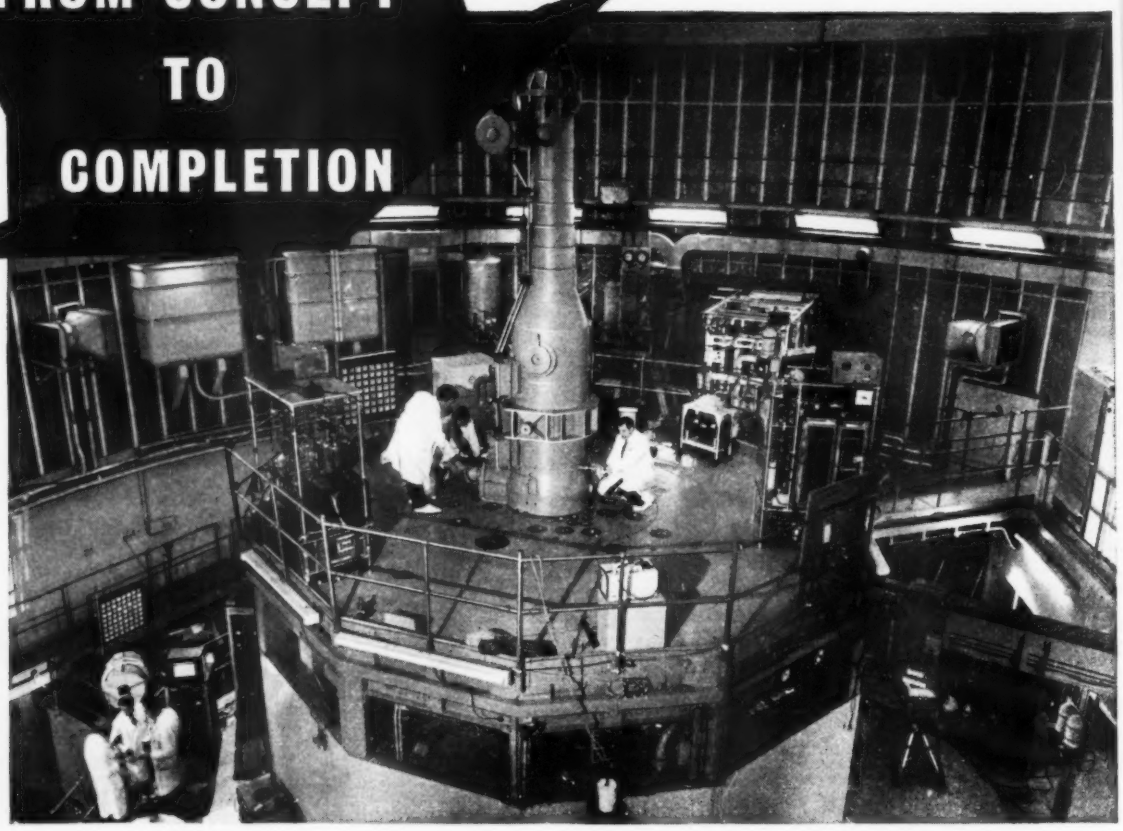
PIONEERS IN THE CREATIVE USE OF THE ATOM

Other offices in: Washington, D.C., U.S.A.; Geneva, Switzerland. Affiliated with: INTERATOM, Bensberg/Cologne, Federal Republic of Germany

Tick No 23 on reply card for further details

FROM CONCEPT TO COMPLETION

The Petroleum, Petrochemical, Chemical and Atomic Energy industries are served by Head Wrightson Processes. The Company handle complete projects from start to finish to meet customers' requirements. For instance, in the field of atomic energy Head Wrightson Processes prepared a detailed design study from Harwell's original concepts and subsequently engineered and supplied Britain's two largest research reactors, 'Dido' and 'Pluto'. Four similar reactors have since been ordered, three for abroad—in Australia, Denmark and Germany. This is just one example of Head Wrightson's ability to take a project through from concept to completion evolving and developing a practical design from experimentally gained data. Such projects demand extensive facilities, a versatile and experienced staff, modern and specialised techniques and high quality craftsmanship to ensure perfection in every detail. Head Wrightson Processes are well equipped to engineer and supply such complex Petroleum, Petrochemical, Chemical and Nuclear plant.

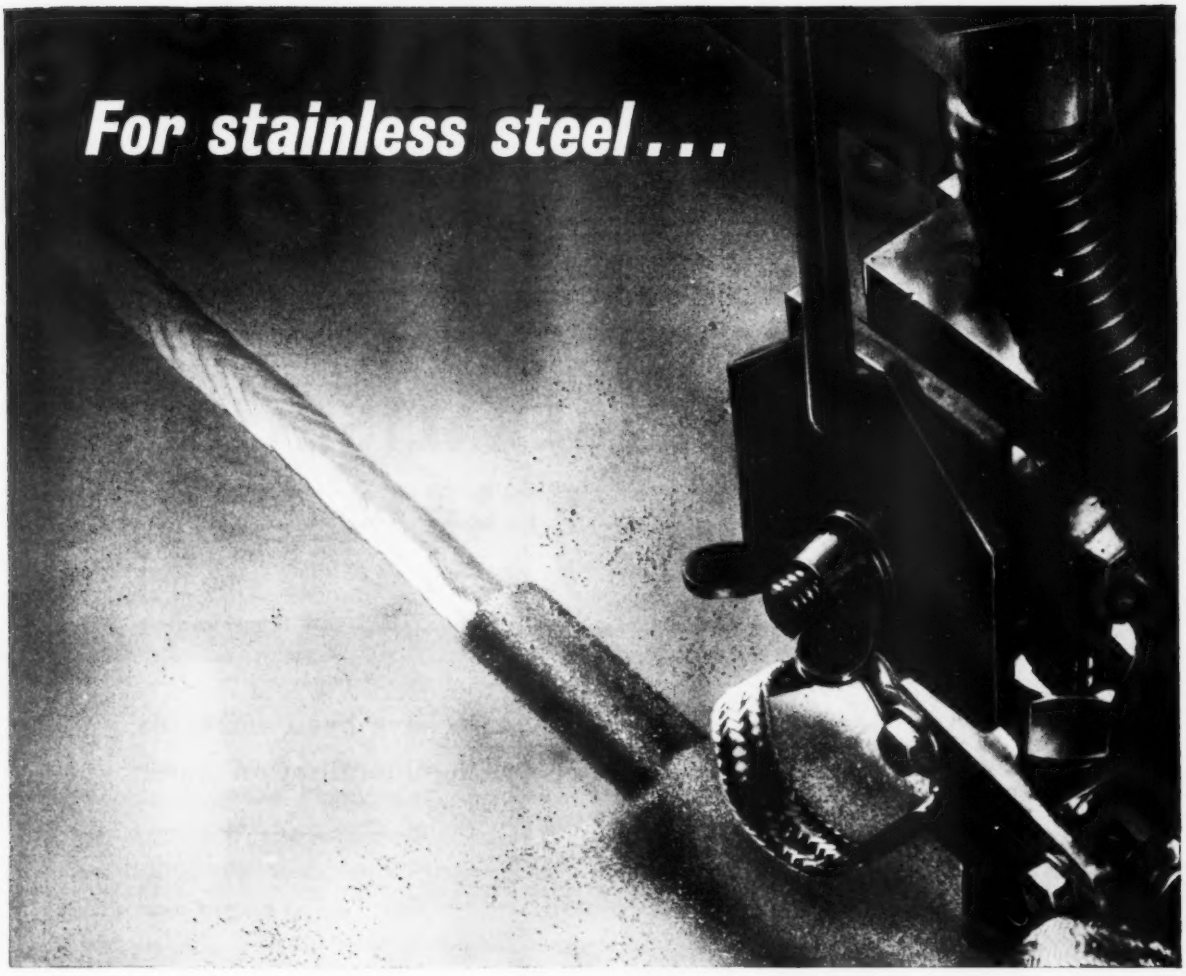


HEAD WRIGHTSON PROCESSES LTD

TEESDALE HOUSE 16/26 BALTIC STREET LONDON EC1

Offices at PO Box 1595 Sydney PO Box 1034 Johannesburg PO Box 2608 Calcutta and 603 Royal Bank Buildings Toronto 1

Tick **No 24** on reply card for further details



MUREX "MURAFLUX S.1"
stainless steel submerged-arc welding flux

The new "Muraflux S.1" granular flux has been specially developed for the automatic welding of stainless steel by the submerged-arc process. The flux is designed for the welding of 18/8 chromium-nickel steels and for use with Murex "Murawire S.W.1" or "Murawire S.W.2" filler wires.

This new Murex flux is suitable for either the single-pass or multi-pass submerged-arc welding of various joints in stainless steel in the flat position and welds of excellent appearance can be produced. A high radiographic standard can be obtained and the welds have good mechanical properties. High impact properties at low temperatures can also be obtained, an important feature in fabrications for sub-zero service.

When used with "Murawire S.W.2", the flux will produce a stabilised deposit and can therefore be used for applications of the 18/8 chromium-nickel steels such as fractionating columns, storage tanks, food vessels and pipe work where resistance to weld decay is essential.

Full details of Murex "Muraflux S.1" submerged-arc welding flux will be supplied on request.

MUREX

A complete service for automatic welding

MUREX WELDING PROCESSES LIMITED, Waltham Cross, Herts.

T33

Tick No 25 on reply card for further details

2 IMPORTANT DEMINERALISATION PLANTS

William Boby & Co. Ltd. have been entrusted with the execution of the demineralisation water treatment plants at:

1 CHEMSTRAND LTD., N. Ireland

(Main Contractors: Messrs. Constructors John Brown)

For their new 'ACRILAN' factory at Coleraine, N. Ireland, Messrs. Chemstrand have installed a 10,000 galls./hr. 'Boby' demineralisation plant for process and boiler feed water.

The plant comprises the following sections:

Coagulation and Settlement — Filtration — Cation Exchange — Weakly basic Anion Exchange — Degassing — Mixed Bed Ion Exchange.

2 VEITSILUOTO O/Y, Finland

The Veitsiluoto paper mills of Finland have installed a 13,400 galls/hr. 'Boby' demineralisation water treatment plant for feed water for boiler working at 1,750 p.s.i.

The plant comprises the following sections:

Coagulation and Settlement—Filtration—Cation Exchange —Weakly basic Anion Exchange — Strongly basic Anion Exchange.

WATER **BOBY** TREATMENT

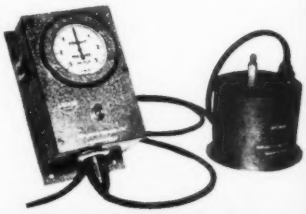
Established in 1875

WILLIAM BOBY & CO. LTD.

RICKMANSWORTH, HERTFORDSHIRE, ENGLAND. Telephone: Rickmansworth 4251*

REMOTE READING DRAUGHT GAUGE

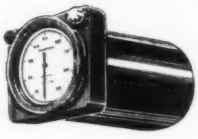
For accurate Remote Indication of very low pressures, all ranges entertained.



ABSOLUTE PRESSURE GAUGE. *Type No. AI.*101

Specially manufactured in mm. Hg Absolute, ranges for the Atomic Energy, Multi-turn Indication, extreme accuracy, Barometrically and Temperature compensated.

SCIENTIFIC INSTRUMENTS

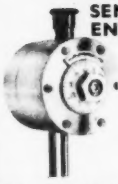


POSITION INDICATORS

For coarse or fine indication of linear movement. Can incorporate Veeder Root counter and setting device for special applications.

SENSITIVE LOW RANGE PRESSURE GAUGES

All ranges from —10 ins. H_2O to +1000 ins. H_2O. Extremely sensitive and accurate, lowest span —1" H_2O to +1" H_2O.



SENSITIVE DIFFERENTIAL PRESSURE SWITCH

For control of straight, differential pressures or flow work.

MINIATURE PRESSURE GAUGE. *Type No. AI.*440.*E.*

Standard Ranges
0—4000 p.s.i.
0— 200 p.s.i.
only .850" diameter.

MINIATURE PRESSURE GAUGE. *Type No. AI.*531.

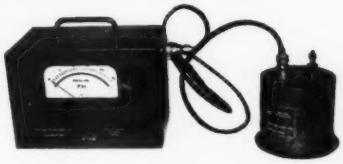
Range 0—5000 p.s.i. Direct Remote Reading versions available. Suitable for Servo work.

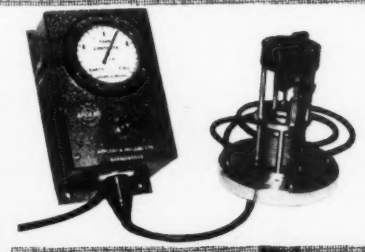
Appleby & Ireland Limited are proud to display these instruments for Nuclear applications, particularly those supplied for the Calder Hall project.

We also supply electrical, gas, aviation, shipping, and many other major industrial plants with specialised instruments.

"REDIFF" REMOTE READING PRESSURE GAUGE

Suitable for measurement of Differential, vacuum, absolute pressure, positive pressure, flow or tank Contents, etc.





TANK CONTENTS GAUGE EQUIPMENT

Remote Indication of Liquid level.

APPLEBY AND IRELAND LIMITED

BASINGSTOKE HAMPSHIRE

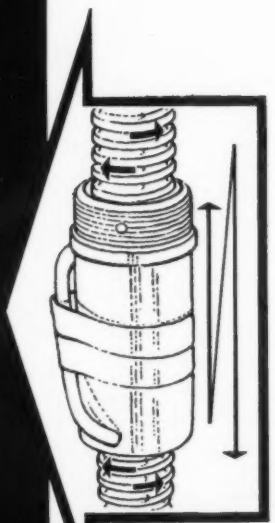
TELEPHONE: Basingstoke 2510/1/2/3
TELEX: 13-626

SENSITIVE MULTI-TURN PRESSURE GAUGE

Extremely accurate ± 1% or ½% upon special request, various ranges and sizes available.

Tick **No 27** on reply card for further details

Bristol Siddeley provide a comprehensive range of high precision recirculating ball and lead screws and splines for universal applications.



HIGH EFFICIENCY

BACK-LASH ELIMINATION

LONG LIFE

LOW MAINTENANCE FACTOR

Up to 80% reduction in power can be achieved for actuation compared with conventional methods.
Ability to run at high temperatures with and without lubrication.
Over 2,700 applications already established in all fields of engineering.
Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.

BRISTOL SIDDELEY ENGINES LIMITED
COVENTRY · ENGLAND

There's no excuse for
CORROSION

Many thousands of tons of steel are lost through corrosion every year and much of this can be saved. *There is a remedy.*
"Superlative" Metal Primer provides a positive protection against corrosion for all ferrous metals. It is quicker and easier to apply than conventional Lead Coatings and is infinitely cheaper. But, as *efficiency* is the factor that matters, and "Superlative" is so economical and so effective, it pays to specify

"Superlative" METAL PRIMER

Kills **CORROSION AT THE SOURCE**

Our Techniservice will gladly answer all enquiries.

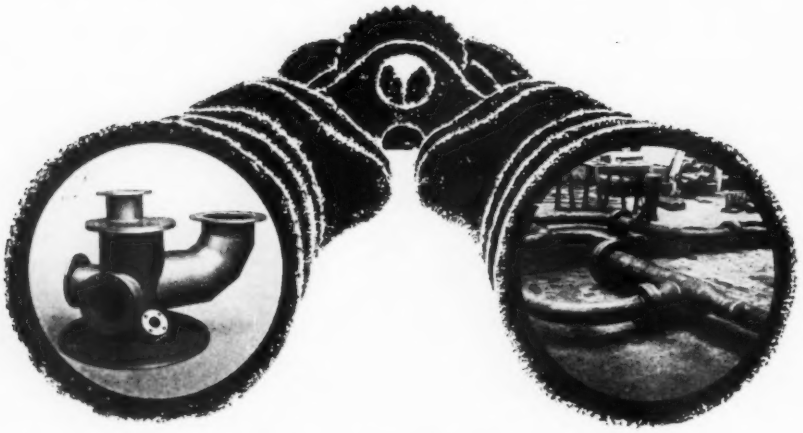
BRITISH PAINTS LIMITED

Portland Road, Newcastle upon Tyne, 2.
Crewe House, Curzon Street, London, W.1., 31, Wapping, Liverpool, 1.

BY APPOINTMENT TO HER MAJESTY QUEEN ELIZABETH II MANUFACTURERS OF PAINT BRITISH PAINTS LIMITED

BELFAST · BIRMINGHAM · BRISTOL · CARDIFF · GLASGOW · LEEDS · MANCHESTER · NORWICH · PLYMOUTH SHEFFIELD · SOUTHAMPTON SWANSEA AND ALL PRINCIPAL TOWNS

for Pipe Fabrication



it's easy to see why STEELS

lead the field

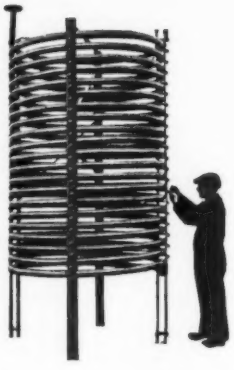
Pipe installations of all types and sizes, fabricated in a wide variety of materials and designed to fulfill the greatest diversity of functions and requirements, are produced by Steels.

Unrivalled throughout the world for efficient and economic operation—Steels' pipe installations are constructed in materials of the highest quality to standards of unimpeachable accuracy.

The swift preparation of pipe layouts from site measurements and drawing is backed by the most advanced and comprehensive metallurgical and testing laboratory facilities. Fabrication practice incorporates all new and established principles of manipulation, welding, flanging and screwing in the normal range of materials used in tube manufacture.

Fabricated to British and American standards.

★ *Mild Steels, Carbon Molybdenum and Chromium Molybdenum Steels.*
★ *Stainless Steels (austenitic and heat resisting).*
★ *Cast Iron.* ★ *Copper and Copper Alloys.*
★ *Aluminium and Aluminium Alloys.* ★ *Plastics.*



Whatever your problem—contact Steels for the answer.

STEELS ENGINEERING INSTALLATIONS LTD.
Sunderland,
and their Associates ARCHIBALD LOW & SONS LTD., Glasgow.
HOME & OVERSEAS SALES OFFICE: 143 Sloane St., S.W.1. Tel: Sloane 6178

231

'Durever' p.v.c. flooring made by Rubber Improvement Ltd., Wellingborough, in the entrance hall of a large laboratory.

When flooring is made from p.v.c.

It's better made from I.C.I. 'Corvic'

WHEN you use 'Corvic' p.v.c. polymers you benefit from the finest research and technical service in the country. I.C.I. put that service at the disposal of all users of p.v.c. Indeed, even if you are only considering using p.v.c. I.C.I. will be glad to help you.

The illustration shows p.v.c. flooring in a large laboratory. It is handsome, hard-wearing, easy to clean and maintain. The p.v.c. used by Rubber Improvement Ltd., is 'Corvic' — there is none better.

'CORVIC'

'Corvic' is the registered trade mark for the p.v.c. polymers manufactured by I.C.I.

IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1

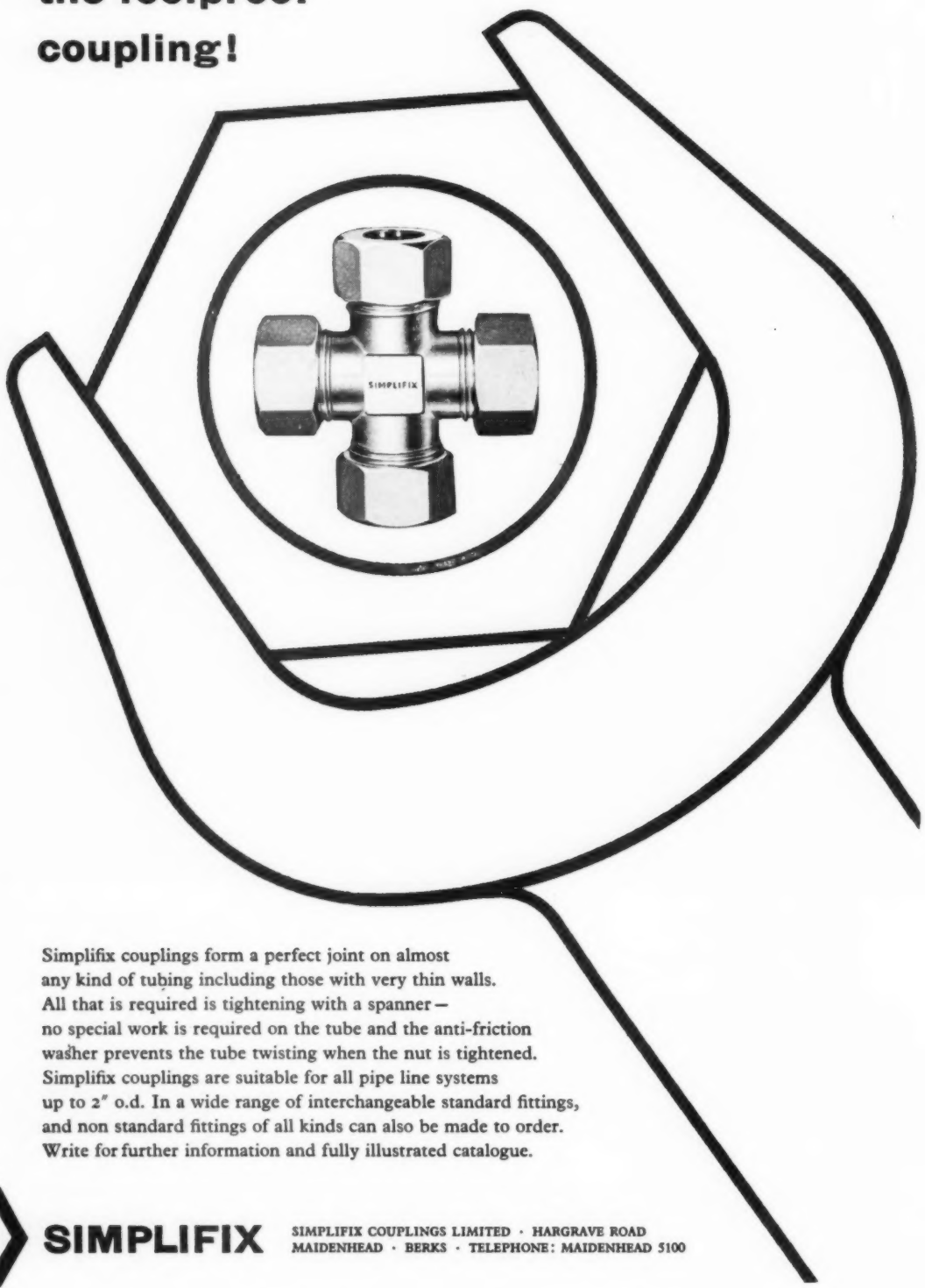
PC.26

ICI

Tick **No 31** on reply card for further details

So simple!

So surely SIMPLIFIX the foolproof coupling!



Simplifix couplings form a perfect joint on almost any kind of tubing including those with very thin walls. All that is required is tightening with a spanner — no special work is required on the tube and the anti-friction washer prevents the tube twisting when the nut is tightened. Simplifix couplings are suitable for all pipe line systems up to 2" o.d. In a wide range of interchangeable standard fittings, and non standard fittings of all kinds can also be made to order. Write for further information and fully illustrated catalogue.

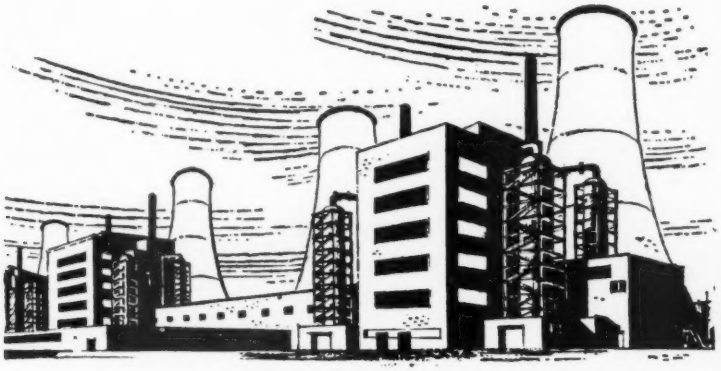
SIMPLIFIX

SIMPLIFIX COUPLINGS LIMITED · HARGRAVE ROAD
MAIDENHEAD · BERKS · TELEPHONE: MAIDENHEAD 5100

We are proud to have been entrusted with large contracts for the thermal insulation of

CHAPELCROSS

NUCLEAR POWER STATION



OVER 300,000 SQUARE FEET OF INSULATED SURFACES

Throughout the years Newalls have built an enviable reputation in the insulation of conventional power stations. This specialised experience is now being drawn upon on an ever growing scale in solving the complex insulation problems in Nuclear Power Development.

At CHAPELCROSS U.K.A.E.A. NUCLEAR POWER STATION for example; under contract to Babcock & Wilcox Ltd., Newalls are carrying out the insulation of the 16 steam raising units and integral piping. The insulation of turbines, blowers, associated auxiliary equipment and piping is being carried out under contract to C. A. Parsons & Co. Ltd.

The principal insulants employed are Newalls own products 85% MAGNESIA and NEWTEMPHEIT and all the application work is being carried out by the Newalls contractual organisation. The latest addition to the Newalls range NEWTHERM Calcium Silicate Insulation has also been applied for the first time on a nuclear power station.

Today's projects (like Chapelcross) need

Newalls INSULATION

NEWALLS INSULATION COMPANY LIMITED

Head Office: Washington, Co. Durham, England. **A member of the TURNER & NEWALL ORGANISATION**

Offices and Depots at: LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF.

Agents and Vendors in most markets abroad.

Nuclear Fabrications

equipment for CLASS I weld dressing

SPECIALLY DEVELOPED
TUNGSTEN CARBIDE
ROTARY CUTTERS
FOR SPEEDS
UP TO 100,000
R.P.M.

S.22 AND S.32 AIR GUNS
OF HIGH POWER FOR
OPTIMUM PERFORMANCE
S.32 HAS SIDE EXHAUST
WILL NOT COOL HOT WELDS

COMPLETE RANGE OF
PNEUMATIC HAMMERS
FOR DE-SCALING WELDS

PNEUMATIC,
HIGH POWER,
CONTROLLED SPEED,
KNOT WHEEL BRUSHING TOOL

B. O. MORRIS LTD., BRITON ROAD, COVENTRY

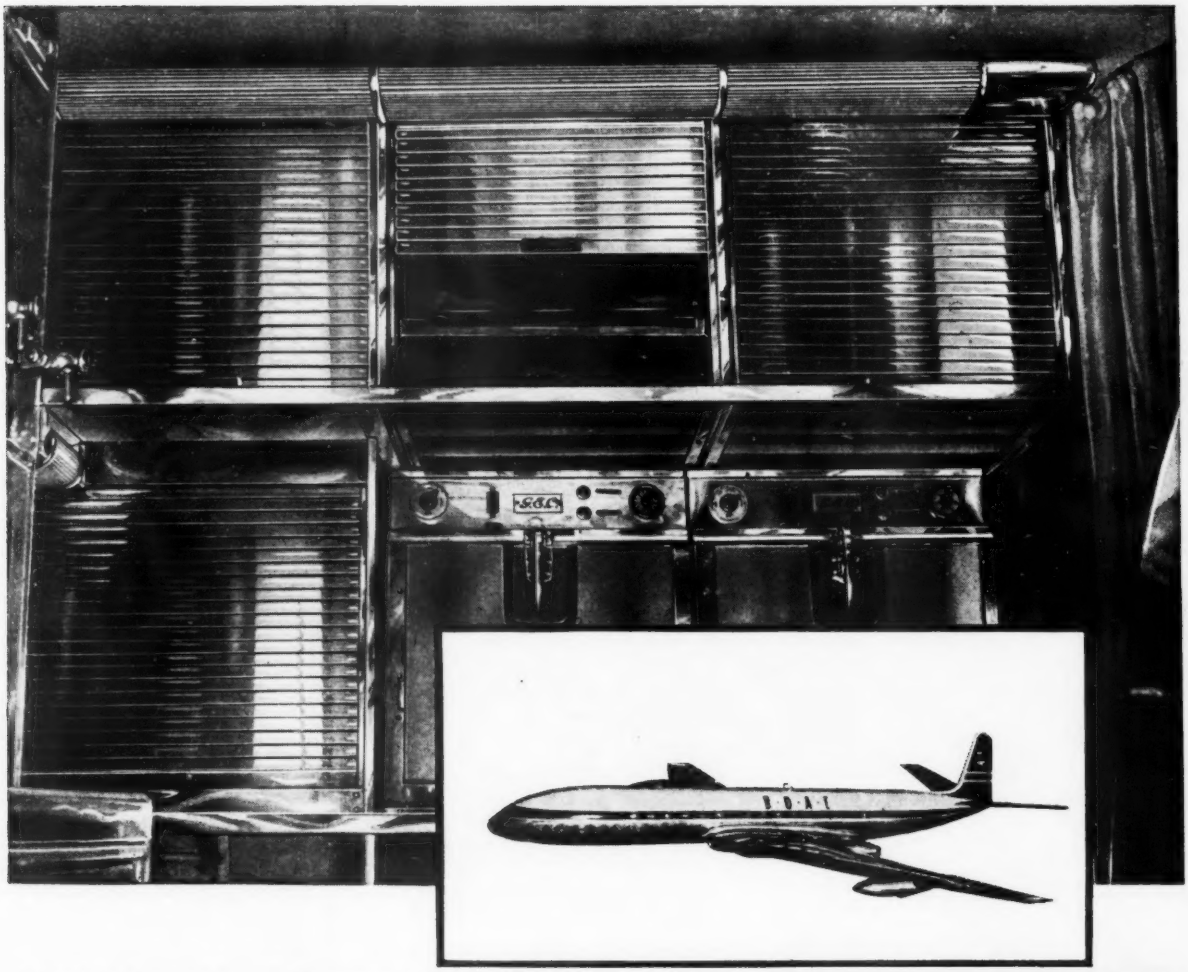
Telephone : **53333 (PBX)**

WILL BE GLAD TO ADVISE

THE MODERN TECHNIQUE

go flying

A new Comet takes the air, and over 50 passengers
settle to the luxury and comfort of excellent food and drink
served from a discretely shuttered galley—8 miles above the earth.
Brady Rolling Shutters incorporate over 80 years design and manufacturing
experience, and made in various sizes possess considerable versatility
in application. The Brady F1, for instance, is a smaller design
specially developed for interior use as in bars, serving hatches, cupboards etc.
The aluminium alloy flat lath construction presents an even flat face
which in various finishes blends harmoniously with any background or decor.
Operated by lift handle, their performance is effortless and reliable.
Send for illustrated leaflet F



G. Brady & Company Limited, Manchester, 4. Telephone COLlyhurst 2797/8/9.

BRADY FOR EVERY OPENING: BRADY ROLLING DOORS IN STEEL, WOOD AND ALUMINIUM
SLIDING SHUTTER DOORS . GRILLES IN STEEL, ALUMINIUM OR NYLON
UP AND OVER DOORS . FIREPROOF DOORS . COLLAPSIBLE GATES
SLIDING DOOR GEAR . ALSO MANUFACTURERS OF BRADY LIFTS

Shaw & Bowden

BRADY
SHUTTERS · ROLLING DOORS

THE DOORS COMMANDING THE WORLD'S LARGEST SALE—
London, Birmingham, Glasgow, Montreal, Port Credit, Hong Kong.

another problem solved with UNISTRUT

INSTALLING INSTRUMENTATION AT AUTOMATED "SEGAS" OIL GASIFICATION PLANT

Three men and a computer control the production of 20 million cubic feet a day of town gas at Britain's first large-scale oil gasification plant. South Eastern Gas Board engineers faced an unusually complex problem in installing the instrumentation network essential for such a high degree of automation.

Unistrut steel channel framing and a pipe cable clamp from the comprehensive range of Unistrut fittings gave the satisfactory solution, with the following advantages . . .

Accurate routing

9½ miles of service pipes—hydraulic, air, electric and instrumentation—run from all parts of the £2½ million plant to the central control room traversing a 253 ft. long covered cable bridge with a drop of 20 ft. at each end. Each pipe has to be precisely located in relation to the control panel and computer and any slight positional errors in erection would be considerably magnified over runs of up to 500 ft. By using Unistrut, in which the position of every fitting is infinitely adjustable before and after attachment, accurate positioning was made possible.

Ease of access

The pipes run through the cable bridge on five 8 ft. high Unistrut racks, four of which are double banked, the five rows of vertical supports being connected at the top to complete the box section and their bases slot-clamped to a horizontal Unistrut channel to allow for heat expansion. Further Unistrut framing carries the pipes to the control room floor where they are attached by clips to Unistrut channels.

In a plan of this type it is of course essential that all servicing be carried out with minimum delay. A false floor of Unistrut beams on which are laid 5′ x 2′ nominal size panels of rubber covered plywood gives immediate access.

Exterior use

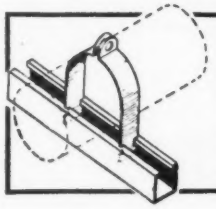
Galvanised Unistrut, available as an alternative to the standard stove-enamelled finish, was used for the trusses supporting the pipes in the open between the gasification units and cable bridge.

Erection economies

Welding and drilling, which would have represented a considerable expense in using conventional support methods for a project of this scale, were eliminated by Unistrut's rapid, self-locating nut assembly. This standardised method was used to form all the framing, in which 10,600 feet of Unistrut were used, and adds to the basic strength of the cold-rolled steel channel by completing a rigid box-section.

Further economies were realised in running the pipes, by using the clip-in fitting shown below, which obviated the need to mark out in advance the precise position of each point of attachment.

This application illustrates some of the on-site advantages of the Unistrut steel-channel framing system, including the fast and economical erection of rigid structures and rapid attachment of services. It cannot however indicate the full scope of the system, which includes a full range of components for supporting every type of service. For further information, please write to the address below.

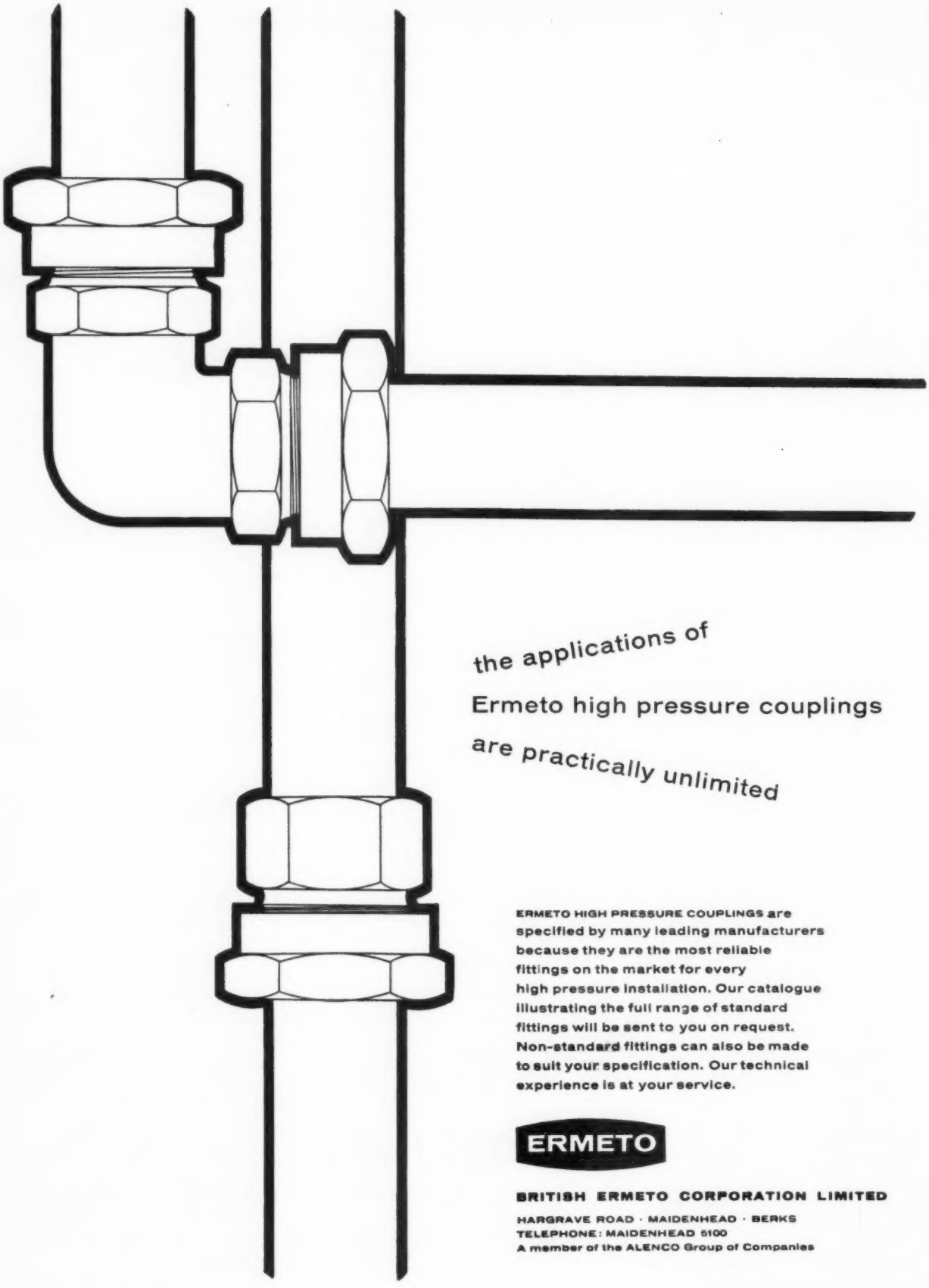


The Unistrut clamp employed throughout this installation typifies the economy of material and effort derived from the Unistrut's special channel section. The two parts of the clamp are located by cut-out lugs against the inside of the channel, so that a single screw and nut is all that is necessary to fasten or release the assembly. (For larger pipes, flanged clamps or rollers are used, bolted to self-locating nuts inserted at the desired point of the continuous-entry channel.)

UNISTRUT

STEEL CHANNEL FRAMING SYSTEM

Please write for technical information to
Unistrut Division of Sankey-Sheldon Ltd. *A member of the Guest, Keen and Nettlefolds Group of Companies.*
43-45 Broadwater Road, Welwyn Garden City, Herts. Telephone: Welwyn Garden City 5406.
UNI 11062



the applications of

Ermeto high pressure couplings

are practically unlimited

ERMETO HIGH PRESSURE COUPLINGS are specified by many leading manufacturers because they are the most reliable fittings on the market for every high pressure installation. Our catalogue illustrating the full range of standard fittings will be sent to you on request. Non-standard fittings can also be made to suit your specification. Our technical experience is at your service.

ERMETO

BRITISH ERMETO CORPORATION LIMITED

HARGRAVE ROAD · MAIDENHEAD · BERKS
TELEPHONE: MAIDENHEAD 5100
A member of the ALENCO Group of Companies

BURGESS

V RANGE

MINIATURE MICRO SWITCHES AND ACTUATORS

PLEASE ASK FOR MORE DETAILS

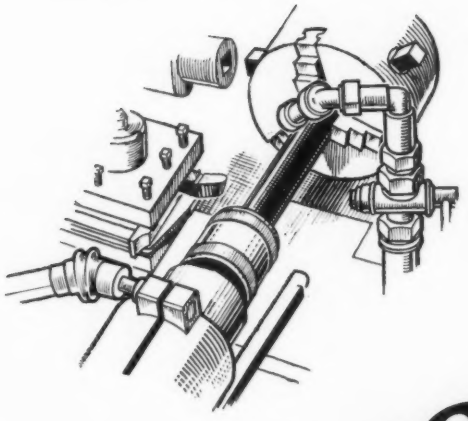
There are many other Miniature Micro Switches and Actuators besides the few illustrated here. All have the famous BURGESS long-life mechanism.

BURGESS PRODUCTS COMPANY LTD

MICRO SWITCH DIVISION

Dukes Way, Team Valley, Gateshead 11.
Telephone: Low Fell 75322 (3 lines) Telex: 53-229
London Office: 127 Victoria Street, S.W.1
Telephone: TATE Gallery 0251 (3 lines)

Tick **No 39** on reply card for further details



REMOTE CONTROL

The remote handling and machining of radio-active materials calls for design and construction of equipment by engineers who have a sound background in special-purpose machinery and machine tool production. More important, they must have a detailed knowledge and appreciation of the problems peculiar to the Nuclear Industry.

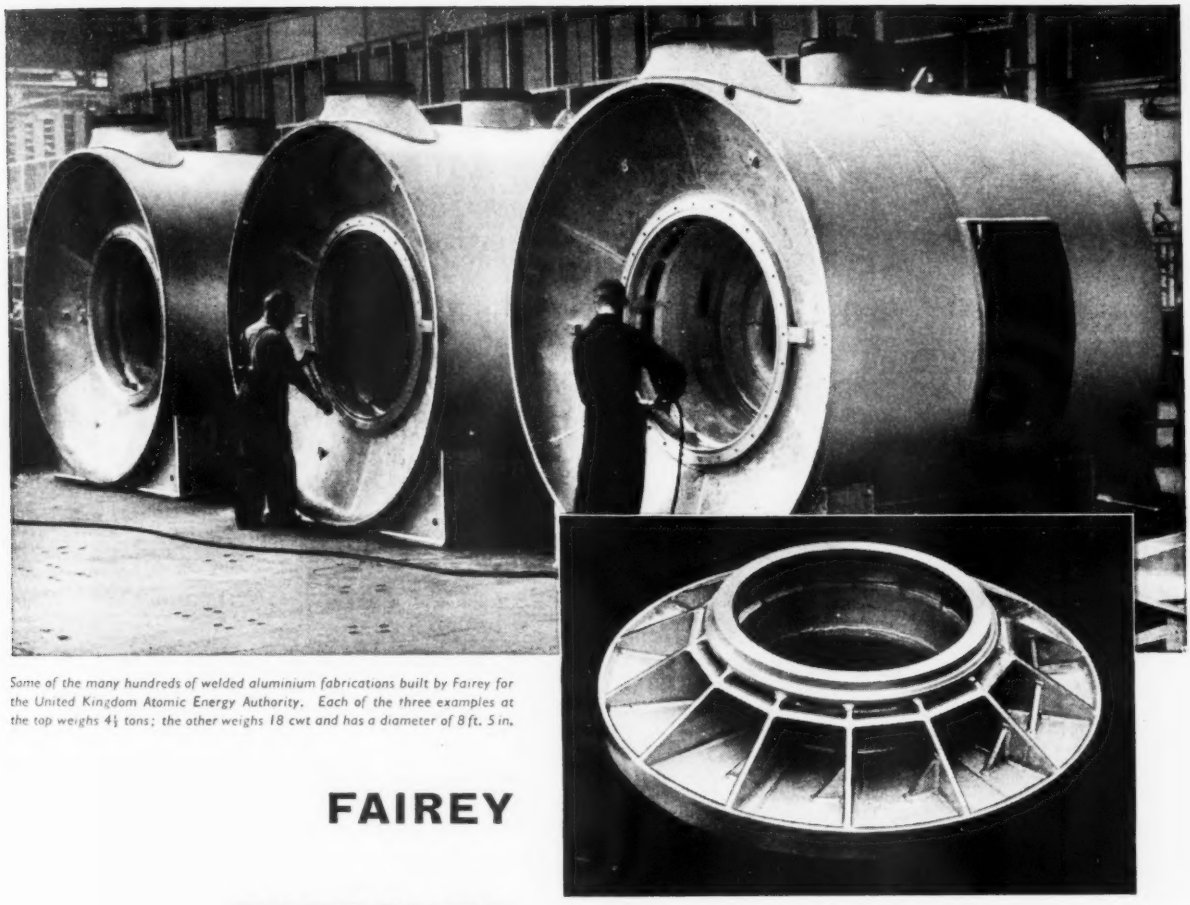
J. EVANS & SON (Portsmouth) LTD

We have both the engineering skill and "know-how." With the close collaboration of the United Kingdom Atomic Energy Authority, we have already designed and installed equipment at the Dounreay, Windscale and Springfields plants.

The illustrations show the exterior and interior installation of a remotely controlled precision lathe for the machining of irradiated fuel elements at Dounreay.

We shall be pleased to visit you at any time and you are cordially invited to our works where selected films and a most interesting range of activities can be seen.

MARCYN WORKS,
GOLDSMITH AVENUE, PORTSMOUTH
Telephone: PORTSMOUTH 32233



Some of the many hundreds of welded aluminium fabrications built by Fairey for the United Kingdom Atomic Energy Authority. Each of the three examples at the top weighs 4¼ tons; the other weighs 18 cwt and has a diameter of 8 ft. 5 in.

FAIREY PRESSURE VESSELS AND STRUCTURES IN STEEL AND ALUMINIUM

Fairey Engineering Ltd. offer a Fabrications facility equal to any in the world.

Pressure Vessels including refinery and chemical vessels, heat-exchangers, and large-diameter pipe, as well as many special types.

Structures such as bridge sections, roof trusses, crane jibs and oil derricks.

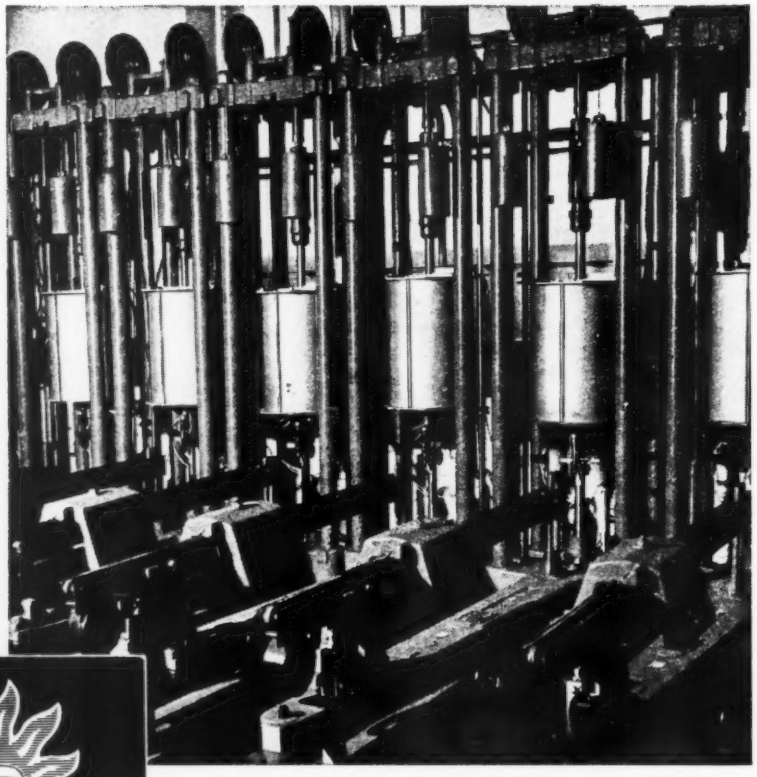
The Fairey Group of Companies provide a full Metallurgical Service, both in plant and at site, including X-Ray, vacuum and ultra-sonic testing; standards met include A.I.D., A.R.B. and U.K.A.E.A. and Lloyds Class I.

For vessels or structures . . . in steel or aluminium . . . talk to Fairey first

FAIREY ENGINEERING
LIMITED

STOCKPORT · CHESHIRE
A Subsidiary of The Fairey Company Limited

Tick **No 41** on reply card for further details



Some of the Creep Testing Machines used in our Research Department.

BEARCOMO

SPECIAL STEELS FOR SPECIAL JOBS!

The making of high-grade steel for a diversity of uses—mechanical, structural and scientific—has placed Consett Iron Company Limited in the front rank of the country's steel producers.

The new demands of Industry have brought about the birth of special steels – steels in which widely incompatible requirements have been met and reconciled . . . such is " BEARCOMO," a special steel we developed scientifically for use in the nuclear reactor shell at Bradwell . . . and now for the nuclear power station reactor at Latina in Italy.

The requirements of nuclear reactors are stringent in the extreme: but the steel we made was put into service with the confidence born of long and continuous exacting Laboratory testing.

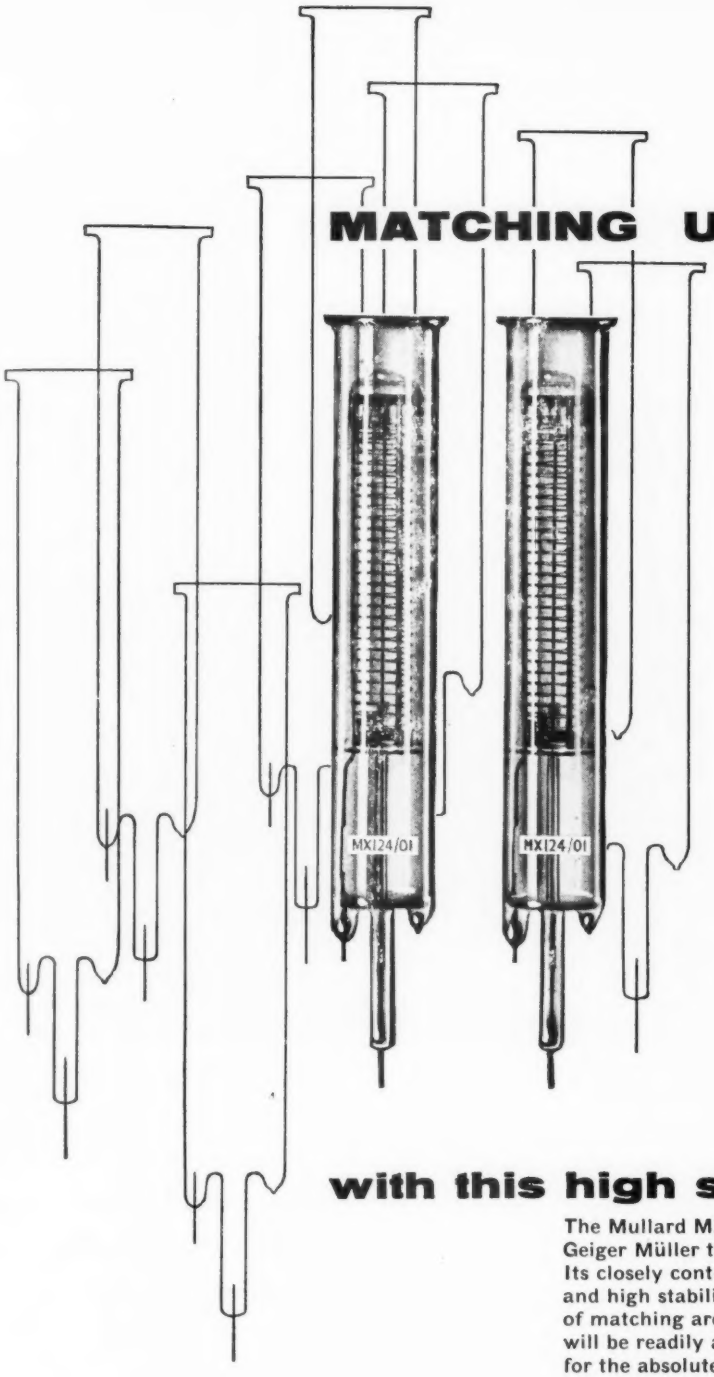
" BEARCOMO " is one of our patented steels – but it is only one of our wide range of special steels for special jobs. Our booklet " Steels for the Job " just published at Consett, describes them in some detail. Perhaps you would like to write for a copy.

Our technical and research departments will also welcome enquiries from anyone whose problem is . . . **STEEL.**

CONSETT IRON COMPANY LIMITED

CONSETT, COUNTY DURHAM. Telephone: Consett 341 (12 lines). Telegrams: Steel, Phone, Consett.

MATCHING UNNECESSARY



with this high stability GM tube

The Mullard MX124/01 is a halogen quenched Geiger Müller tube designed for liquid sampling. Its closely controlled operating characteristics and high stability means that the problems of matching are eliminated—an advantage that will be readily appreciated by those using G.M. Tubes for the absolute assay of radioactive solutions and the measurement of standard sources. Write now for details of this tube and others in the Mullard range.

Mullard X-RAY DIVISION

MULLARD LIMITED, X-RAY DIVISION, NEW ROAD, MITCHAM JUNCTION, SURREY. Telephone: MITcham 3471
MXR513

A Vital contribution to Atomic Power . . .

"WANDLESIDE"

ARMOURED CABLE

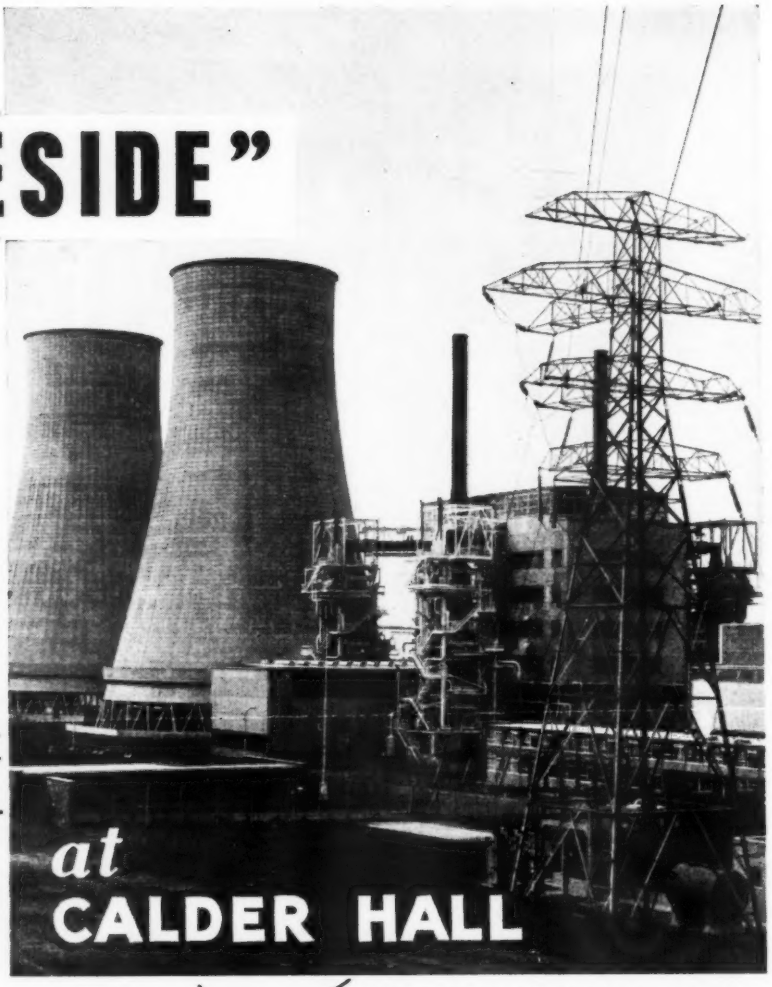


Photo by courtesy U.K. Atomic Energy Authority

With the advancement of Atomic Power, cables must play an important part in the efficiency and reliability in the production of Nuclear Energy. Only the best is good enough and Wandleside Cables are eminently suitable.

WANDLESIDE CABLES *for Nuclear Energy*

WANDLESIDE CABLE WORKS LTD. 106 GARRATT LANE WANDSWORTH LONDON, S.W.18

One of FALKS Group

Telephone : VANdyke 7544 (5 lines) *Telegrams : Wandleside, London*

C

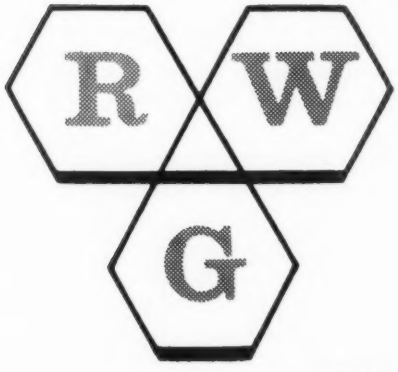
Atomic Power at Trawsfynydd

The Contract for the Atomic Power Station to be built at Trawsfynydd in North Wales has been awarded by the Central Electricity Generating Board to . . . . . **Atomic Power Constructions Limited**

This latest Atomic Station will feed into the national grid 500,000 kilowatts of electricity.

The whole of the generating plant for Trawsfynydd, comprising the steam turbo-alternators with the condensing plant and feed-heating systems, and the blowers to circulate the hot gas through the reactors, will be built by . . . . . **Richardsons, Westgarth & Co. Ltd.**

A MEMBER OF ATOMIC POWER CONSTRUCTIONS LIMITED



MEMBER COMPANIES OF ATOMIC POWER CONSTRUCTIONS LIMITED

Crompton Parkinson Ltd. — International Combustion (Holdings) Ltd.

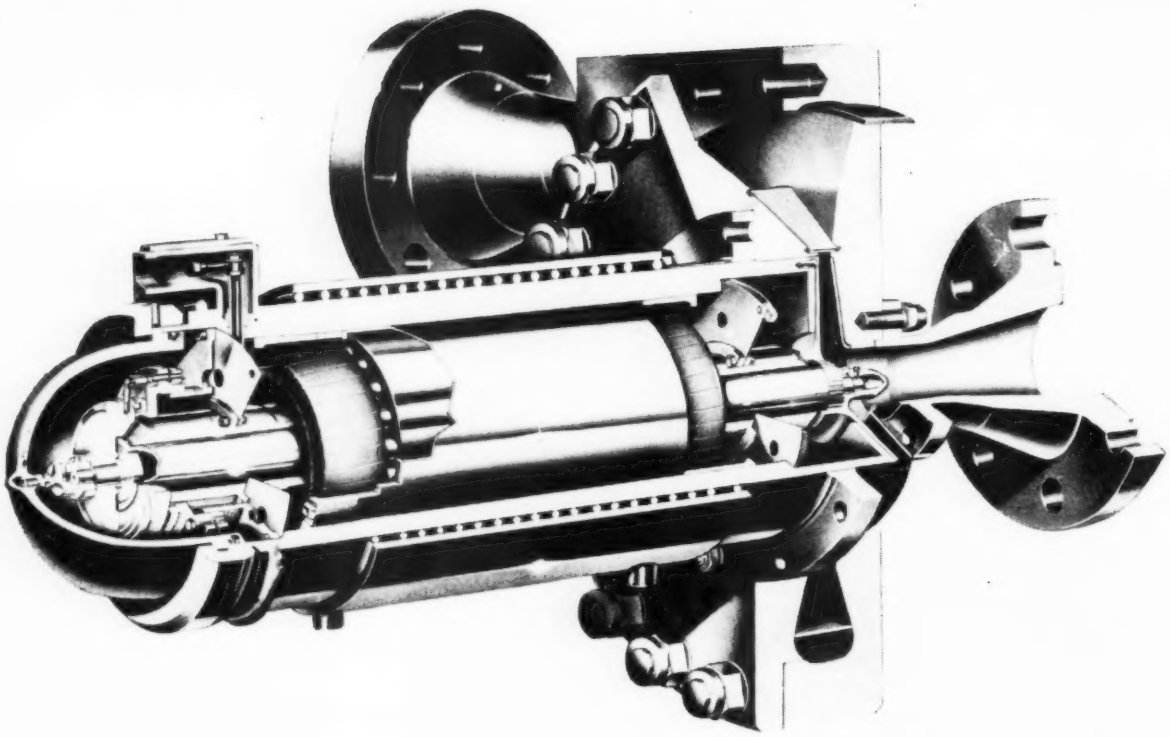
Fairey Aviation Limited — Richardsons, Westgarth & Co. Ltd.

ASSOCIATES:- Nuclear Civil Constructors.
(Trollope & Colls Ltd. and Holland & Hannen and Cubitts Ltd.)

THE RICHARDSONS WESTGARTH GROUP

WALLSEND · SUNDERLAND · HARTLEPOOL · IMMINGHAM AND LONDON

Tick No 45 on reply card for further details



BRISTOL SIDDELEY

HAVE DESIGNED A RANGE OF GAS BEARING COMPRESSORS CAPABLE OF HANDLING GASES UP TO...

2,000 psi and 700°C

with input powers up to 2,000 hp
They have many advantages
They are:

Free from lubricant contamination

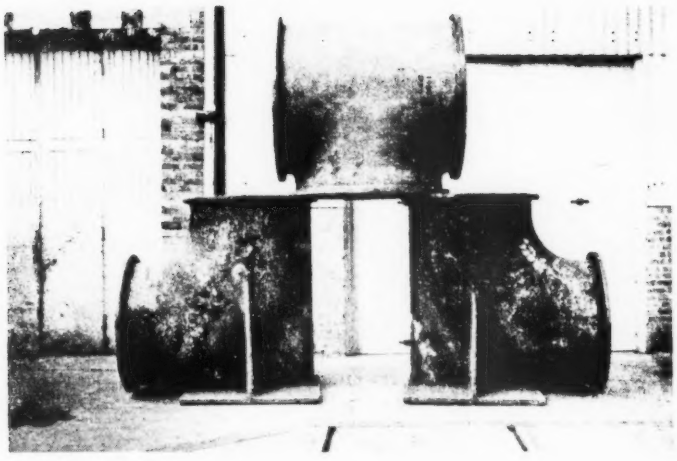
Totally enclosed, needing no mechanical seals

Practically maintenance-free

Capable of operating over a wide range of temperatures and pressures

BRISTOL SIDDELEY ENGINES LIMITED · COVENTRY · ENGLAND

CLAY CROSS



for
water
cooling
and
drainage
systems

VERTICALLY CAST IRON PIPES
SPECIAL PIPE CASTINGS

BENDS, TEES, TAPERS, ETC. UP TO 84" DIAM.

SPUN IRON PIPES

SCREWED SPUN FLANGED

work in progress for the nuclear industry

CLAY CROSS (IRON & FOUNDRIES) LTD.

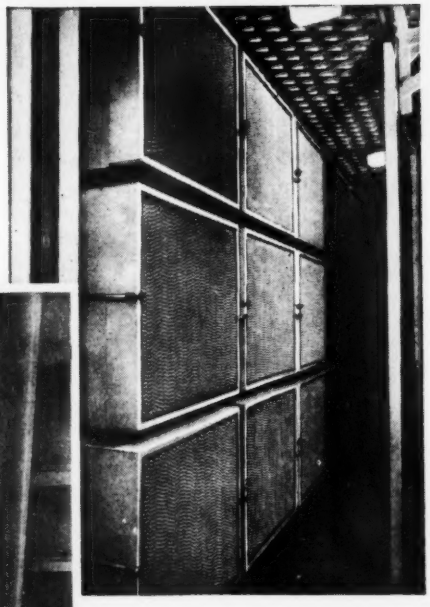
CLAY CROSS, DERBYSHIRE

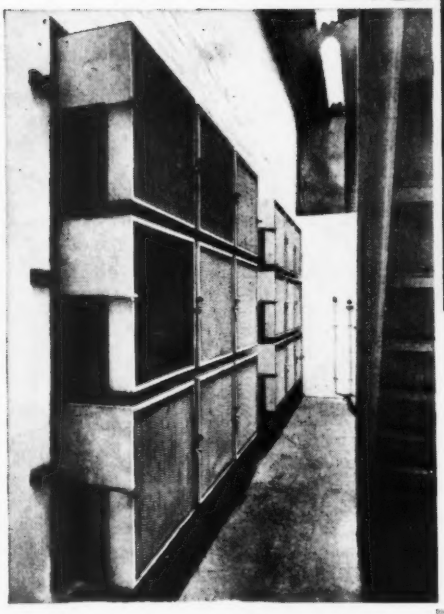
Telephone: Clay Cross 2151 *Telegrams: Jackson, Clay Cross*

Tick **No 47** on reply card for further details

you can't
drop
a spanner
in the
works
with this flooring
Tailored to your specifications
No layout too intricate!
SAFETREAD
WELDED STEEL FLOORING
Engineers everywhere are aware of the unique design and construction of 'Safetread' flooring—its construction has gained universal appeal as it provides the greatest possible strength and rigidity with a minimum use of steel, thus enabling valuable economies to be effected in supporting members.
With Safetread's welded construction, nothing can work loose or cause chattering through vibration—its design enables maximum light and air penetration and yet the danger of tools or other similar objects falling through is reduced to an absolute minimum.
Write today for a catalogue of Safetread "tailor-made" flooring—amply illustrated, it contains deflection tables, safe-load tables, and a wealth of useful information for the man with a flooring problem.
ALLAN KENNEDY & CO · LTD
MARITIME STREET · STOCKTON-ON-TEES
Telephones: STOCKTON 65484 (4 lines) · Grams: 'GRATING' STOCKTON-ON-TEES
London Office: ASFORD HOUSE WILTON ROAD LONDON SW1 · Tel: VICtoria 2211

Vokes at Harwell

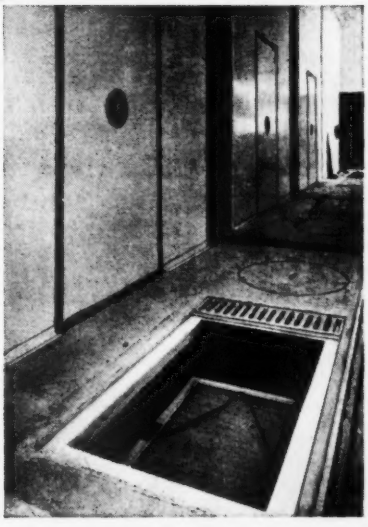




Vokes 44 'Absolute' filters on the intake side.

Vokes 55 'Absolute' filters on the extract side.

A Vokes 55 'Absolute' under-floor cell filter in the operating area.



In the High Activity Materials Handling Building at Harwell, Vokes 'Absolute' filters were specified by the Ministry of Works for the ventilation plant. Already in use at Aldermaston and Dounreay Vokes 'Absolute' filters provide the highest standard of filtration at present available — 99·95% tested efficiency against a methylene-blue dust cloud. Each filter is tested before despatch and is unreservedly guaranteed. Vokes 'Absolute' filters, and other Vokes types, are playing and will continue to play a vital part in Britain's nuclear power programme. Our engineers will be glad to give you full details of the Vokes 'Absolute' filter.

VOKES

VOKES LTD · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines)

Telegrams & Cables: Vokesacess, Guildford, Telex

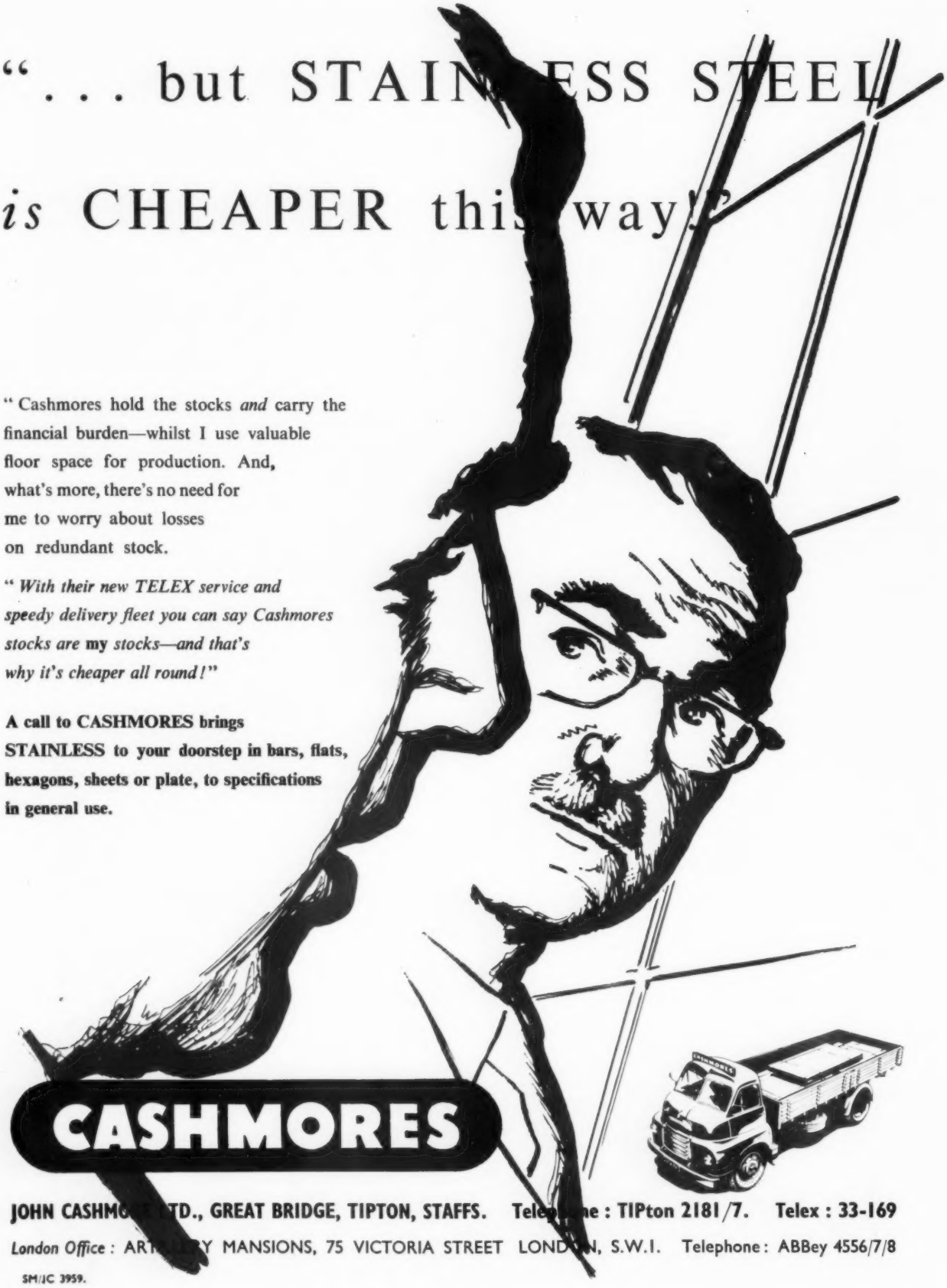
Telex: 13-535 Vokesacess, Gfd.

Vokes Australia Pty. Ltd., Sydney — *Represented throughout the World*

VOKES—Air and Gas Filters for Chemical, Nuclear Energy, Oil Refinery, and Pharmaceutical applications etc; Air conditioning filters; Compressed air pipe line filters, Air, Oil, and Fuel filters for Diesel, Gas Turbine, and other i/c engines; Hydraulic filters; Silencers for Engines, Fans and Blowers; High efficiency Multi Cyclones

V313

"... but STAINLESS STEEL *is* CHEAPER this way!"



" Cashmores hold the stocks *and* carry the financial burden—whilst I use valuable floor space for production. And, what's more, there's no need for me to worry about losses on redundant stock.

" *With their new TELEX service and speedy delivery fleet you can say Cashmores stocks are* **my** *stocks—and that's why it's cheaper all round!*"

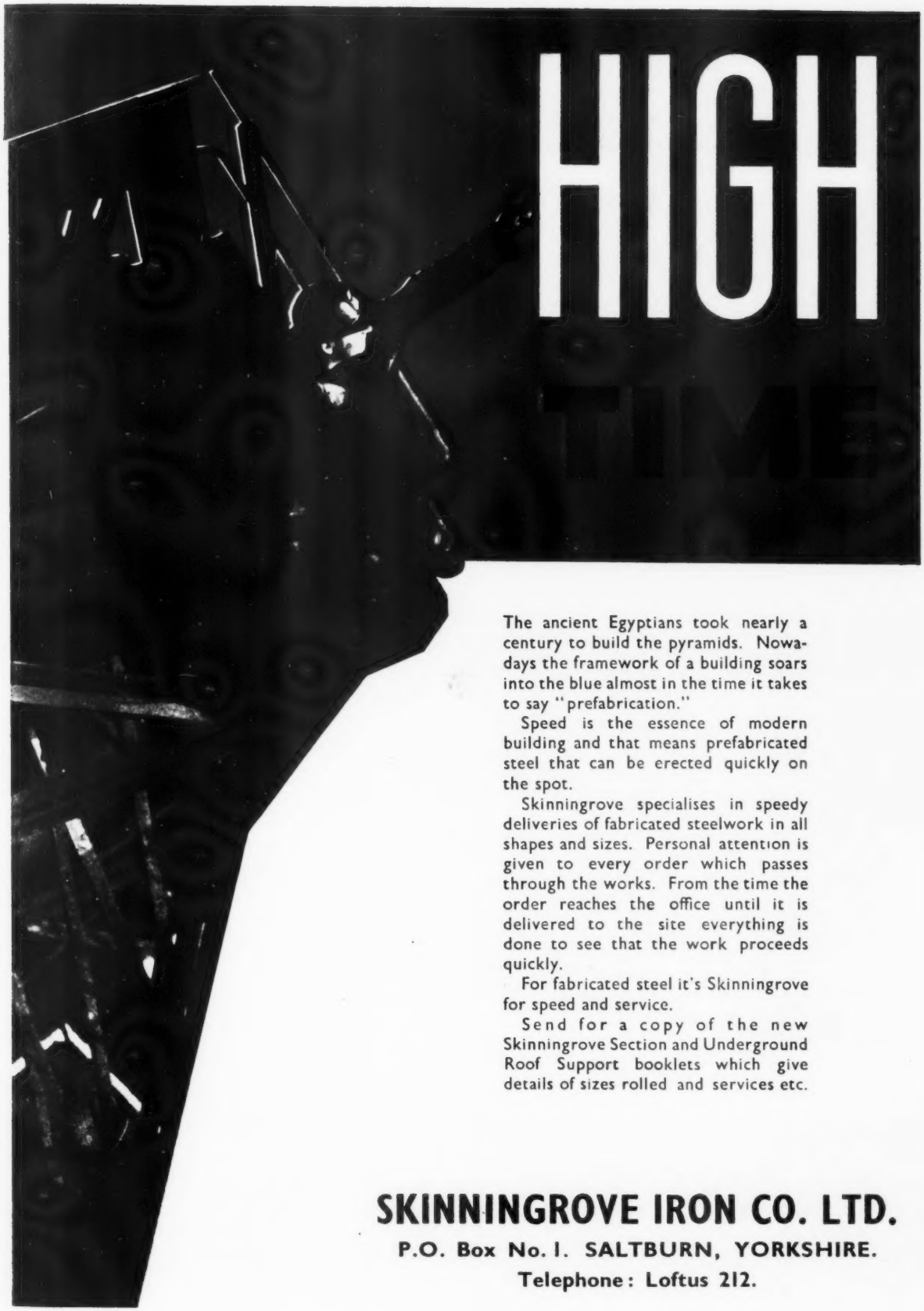
A call to CASHMORES brings STAINLESS to your doorstep in bars, flats, hexagons, sheets or plate, to specifications in general use.

CASHMORES

JOHN CASHMORE LTD., GREAT BRIDGE, TIPTON, STAFFS. Telephone : TIPton 2181/7. Telex : 33-169

London Office : ARTILLERY MANSIONS, 75 VICTORIA STREET LONDON, S.W.1. Telephone : ABBey 4556/7/8

SM/JC 3959.



HIGH TIME

The ancient Egyptians took nearly a century to build the pyramids. Nowadays the framework of a building soars into the blue almost in the time it takes to say "prefabrication."

Speed is the essence of modern building and that means prefabricated steel that can be erected quickly on the spot.

Skinningrove specialises in speedy deliveries of fabricated steelwork in all shapes and sizes. Personal attention is given to every order which passes through the works. From the time the order reaches the office until it is delivered to the site everything is done to see that the work proceeds quickly.

For fabricated steel it's Skinningrove for speed and service.

Send for a copy of the new Skinningrove Section and Underground Roof Support booklets which give details of sizes rolled and services etc.

SKINNINGROVE IRON CO. LTD.

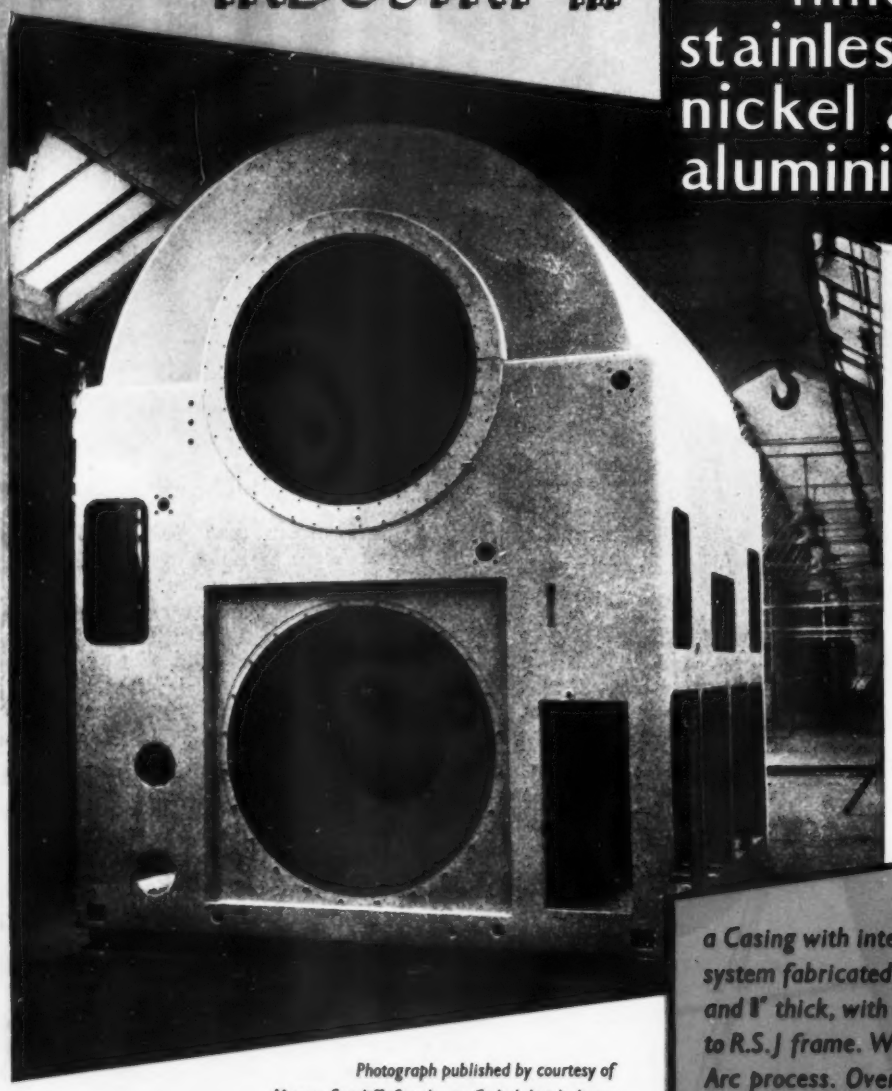
P.O. Box No. 1. SALTBURN, YORKSHIRE.

Telephone: Loftus 212.

Tick **No 51** on reply card for further details

FABRICATORS to INDUSTRY in

.... mild steel, stainless steel, nickel and aluminium etc.



Photograph published by courtesy of Messrs. Sutcliffe Speakman Co.Ltd, Leigh, Lancs.

Illustration shows a Casing with internal baffle and fan system fabricated in mild steel ½", ¼" and ⅛" thick, with base sheets welded to R.S.J frame. Welded by Metallic-Arc process. Overall Dimensions approx: 12' long x 8' wide x 12' high Weight 7 tons.

UNIVERSAL BOILERS & ENGINEERING CO. LTD

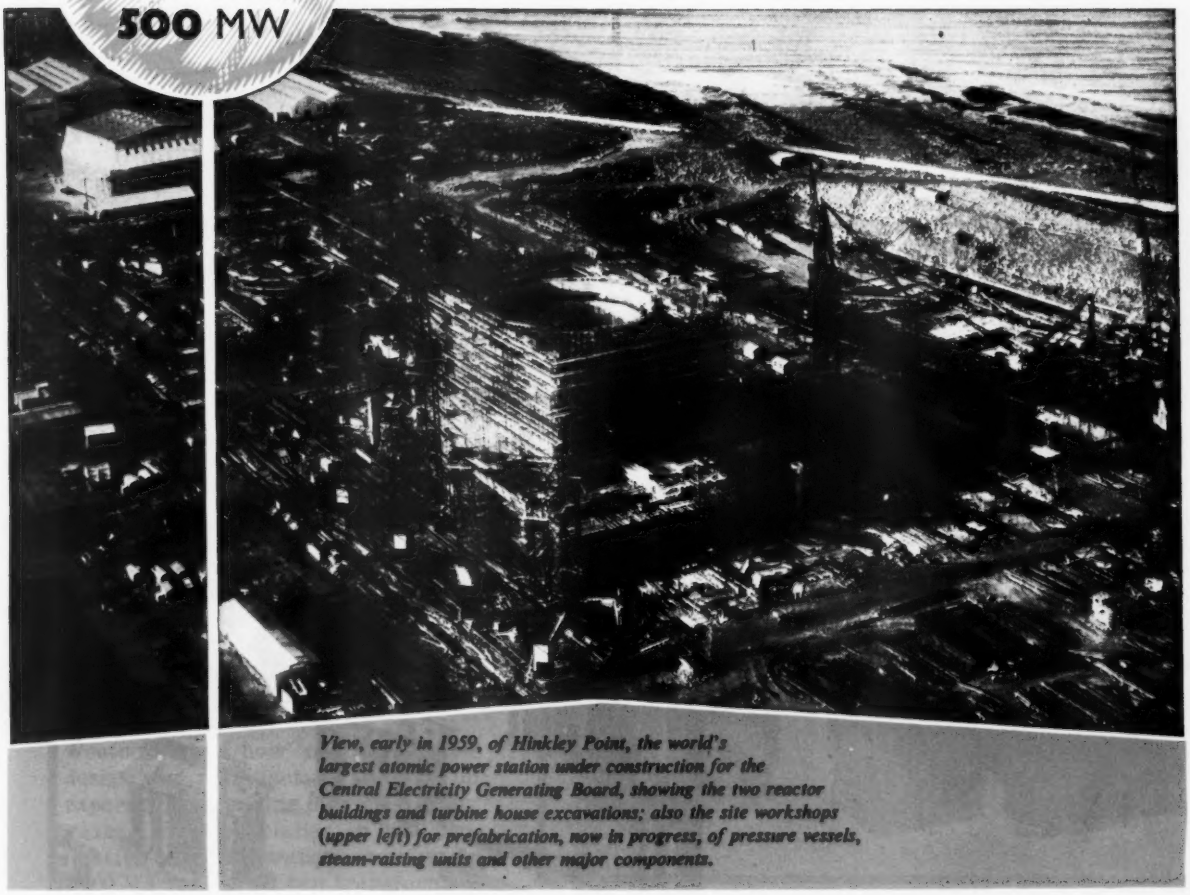
HEAD OFFICE: FULLEDGE WORKS - BURNLEY - LANCASHIRE - ENGLAND
Telephone: 3121/2 and 3203 Burnley (3 Lines) Telegrams: 'UNIVERSAL' Burnley

Associated with BURNLEY AIRCRAFT PRODUCTS LTD. Fulledge Works Burnley Telephone: 3121/2
GROSVENOR STREET, STONEYHOLME, BURNLEY Telephone: 3184
and BRITANNIA WORKS, QUEENSGATE, BURNLEY Telephone: 4102

HINKLEY POINT

operation PROGRESS

500 MW



View, early in 1959, of Hinkley Point, the world's largest atomic power station under construction for the Central Electricity Generating Board, showing the two reactor buildings and turbine house excavations; also the site workshops (upper left) for prefabrication, now in progress, of pressure vessels, steam-raising units and other major components.

150 MW

250 MW

Progress by this Group, designers and builders of the world's first 500 MW atomic power station, is being made not only at Hinkley Point but also for export. For stations of similar type for construction overseas, detailed design studies have been completed for outputs of 150 MW and 250 MW.

ENGLISH ELECTRIC

THE ENGLISH ELECTRIC COMPANY
Limited, Marconi House, Strand, London, W.C.2
GA. 4

BABCOCK & WILCOX

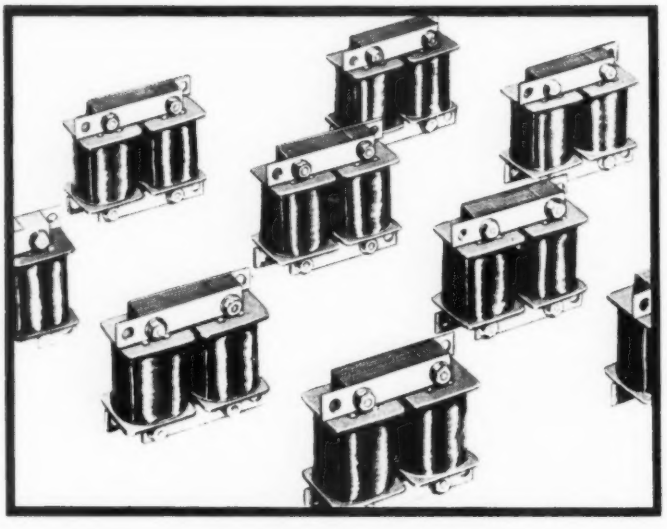
BABCOCK & WILCOX LIMITED
Babcock House, Euston Road, London, N.W.1

TAYLOR WOODROW

TAYLOR WOODROW CONSTRUCTION
Limited, London

Tick **No 53** on reply card for further details

leads to your needs in TRANSFORMERS



One of a range of special transformers and chokes made to customer's specification.

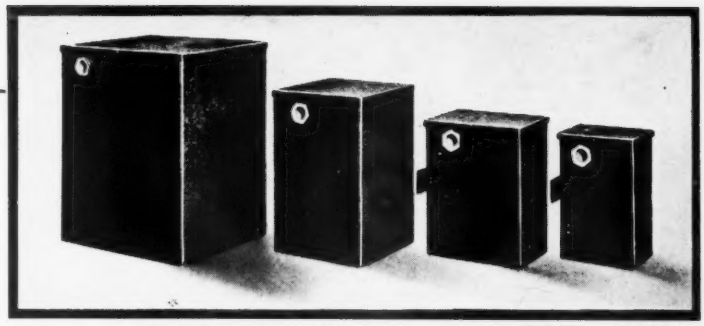
WESTOOL LIMITED

ST. HELEN'S AUCKLAND, CO. DURHAM
Phone: West Auckland 551 5 Grams: Solenoid, West Auckland

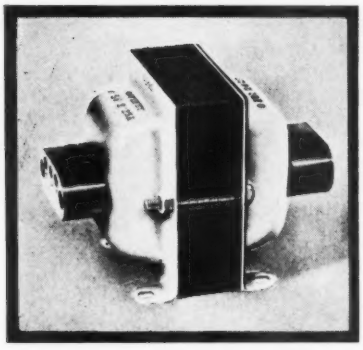
Birmingham Office:
7 Newhall St., Birmingham 3
Telephone: Central 3901

Westool also make A.C. & D.C. Solenoids, Coil's & Coil Winding Machines, Warner Electric Brakes & Clutches, Air Conditioners, etc., and are Sole Selling Agents for the relays, sensing devices and micro-components manufactured by A. F. Beeson and Partner Ltd.

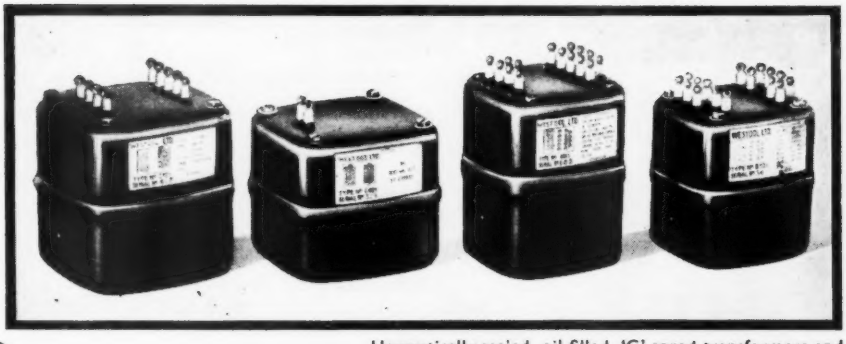
WESTOOL



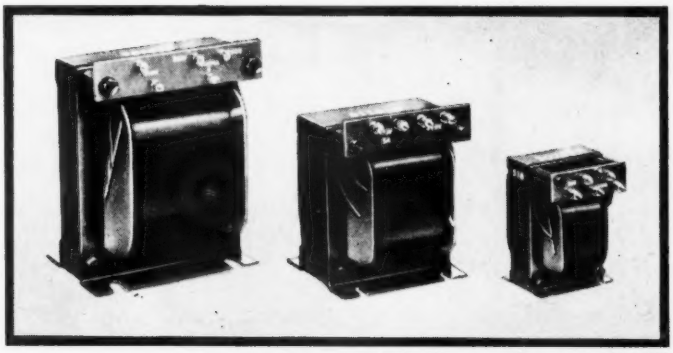
Encased transformer for indoor use made to B.S.171 or B.S.794 in ratings up to 5 KVA single phase and 20 KVA three phase at 50 cps.



Fully shrouded single phase transformer for ratings up to 500 VA at 50 cps.



Hermetically sealed, oil filled, 'C' cored transformers and chokes to RCL 215 for ratings up to 1½ KVA at 50 cps.

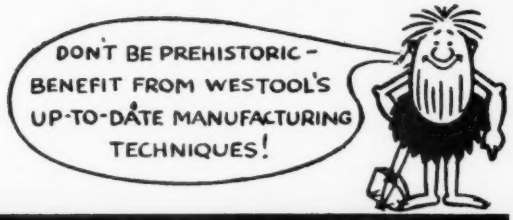


Open type single phase transformers to B.S.171 or B.S.2214 for ratings up to 5 KVA at 50 cps.

You can place complete reliance on Westool transformers which are made and tested in a modern factory on the most up-to-date equipment.

Westool 'know-how' on transformer design and manufacture is based on experience extending over very many years. They specialise in the production of small transformers up to 2,000 VA for sealed can transformers and 5 KVA single phase—18 KVA three phase.

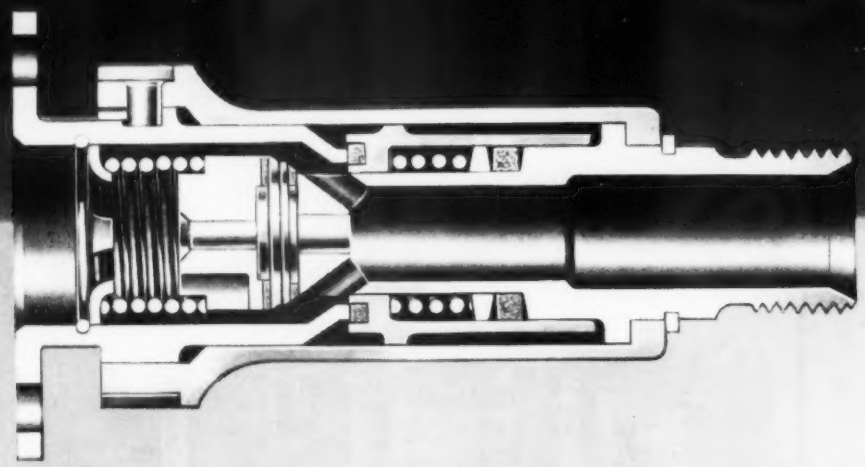
Make use of the Westool technical advisory service and send now for binder of data sheets covering standard types.



TRANSFORMERS

Tick No 55 on reply card for further details

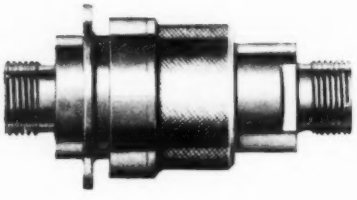
SELF-SEALING



SELF-SEALING COUPLINGS OF BAYONET OR SCREW TYPES

These couplings have been supplied for some considerable time for use with Helium, Heavy Water, etc. and they can be supplied in stainless steel for high temperature conditions up to +180°C. They are completely hermetically self-sealing when disconnected but automatically provide a clear passageway when re-coupled. They are made in a range of sizes from $\frac{1}{4}$" to $\frac{3}{8}$" bore.

Our Technical Staff are always ready to discuss your problems.



Above: a typical Lockheed-Avery coupling in the $\frac{1}{4}$" - $\frac{1}{2}$" range.

Lockheed-Avery coupling in the $\frac{3}{4}$" size. Other variations are also available.

Lockheed Avery

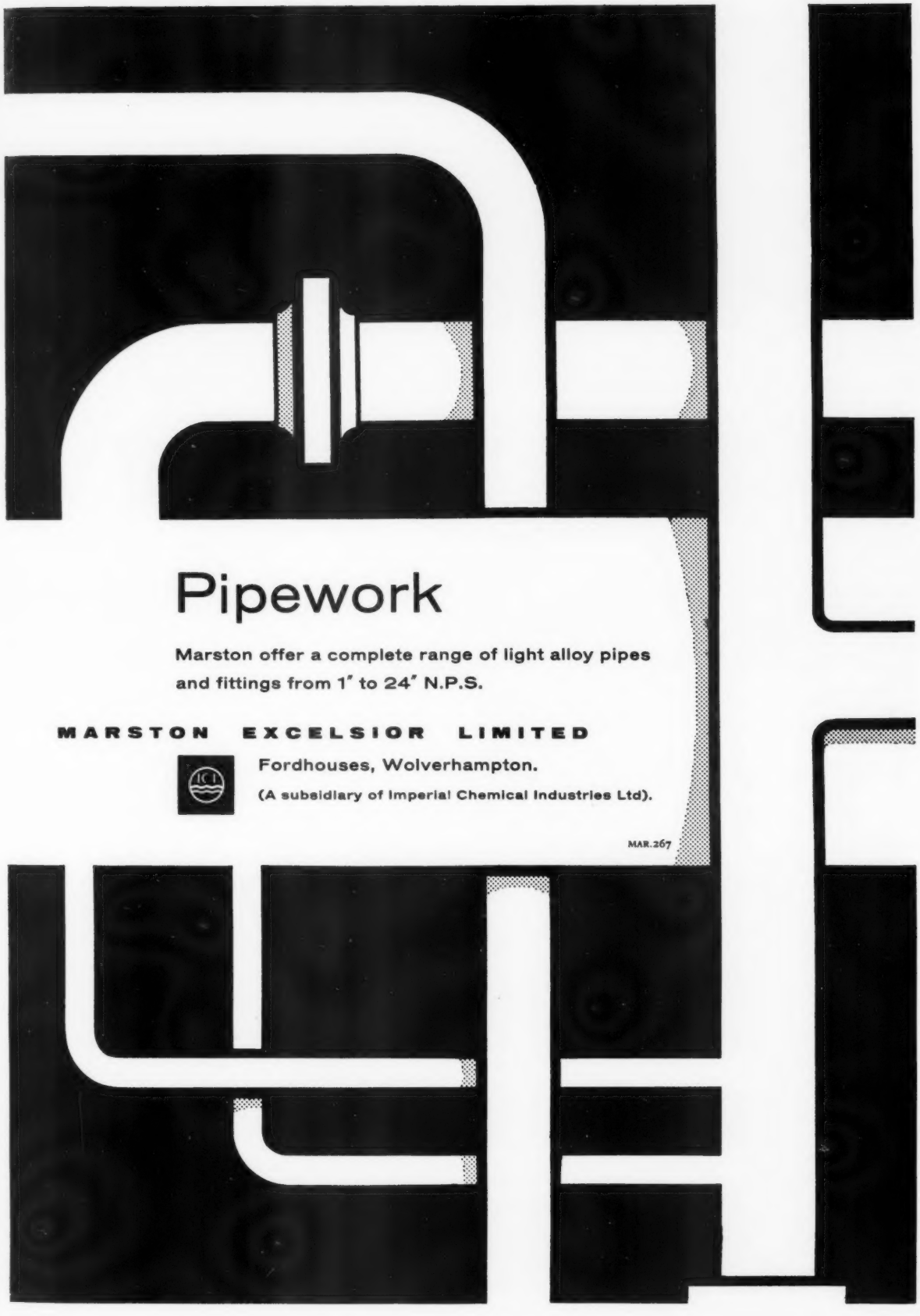
(REGD. TRADE MARK)

One of the Automotive Products Group

AVERY DIVISION, LOCKHEED PRECISION PRODUCTS LIMITED

SHAW ROAD, SPEKE, LIVERPOOL, 24 *Telephone: Hunts Cross 2121 Telegrams: Lockheed Liverpool 24*

Tick No 56 on reply card for further details


Pipework
Marston offer a complete range of light alloy pipes and fittings from 1″ to 24″ N.P.S.
MARSTON EXCELSIOR LIMITED
Fordhouses, Wolverhampton.
(A subsidiary of Imperial Chemical Industries Ltd).
MAR.267

Tick No 57 on reply card for further details

Rolled Rings

For Aircraft Nuclear and other Engineering purposes

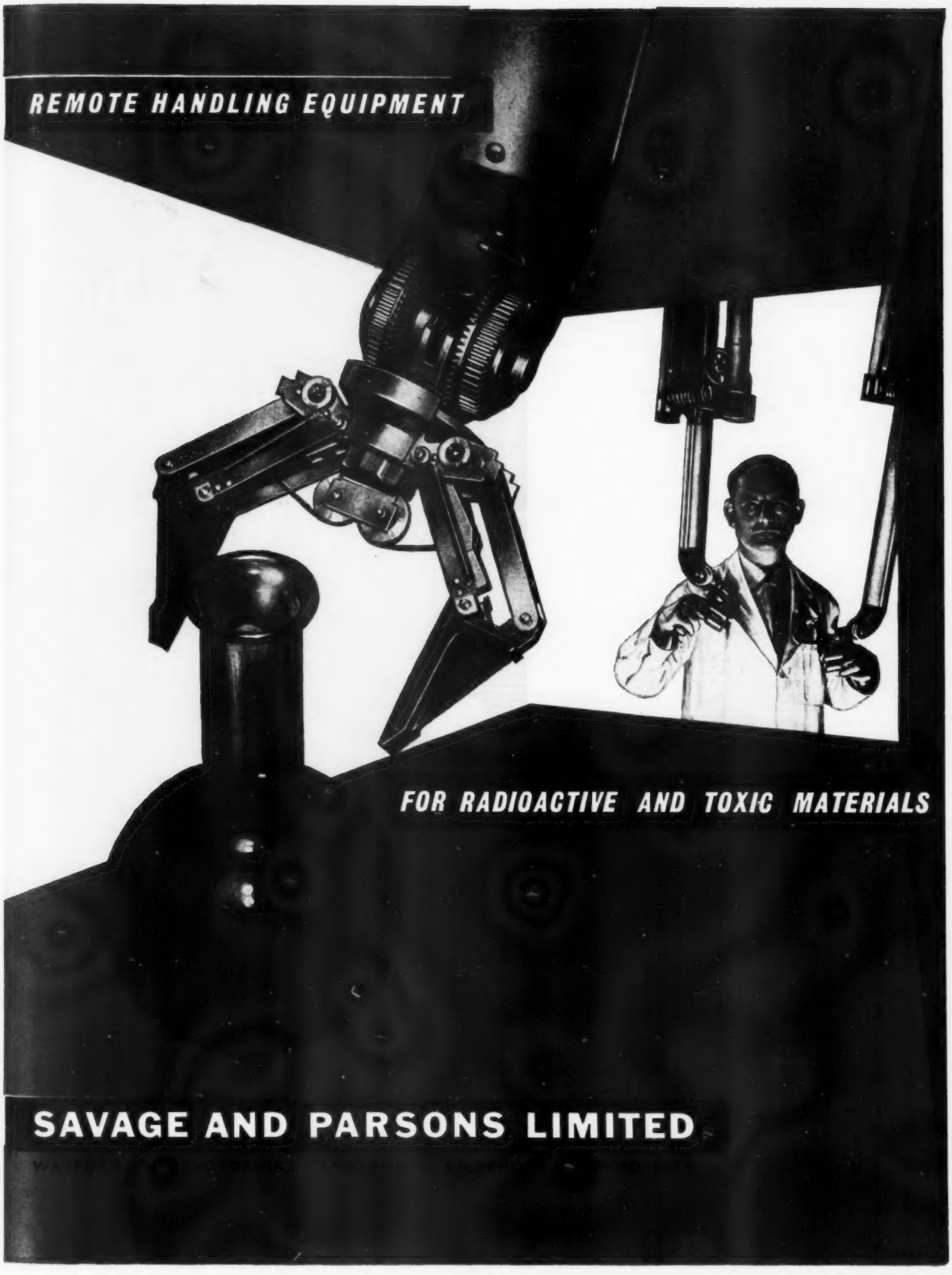
Rolled Rings in Carbon, Alloy and Special Steels for the Aircraft, Electrical, Nuclear Power, Ball Bearings and General Engineering Industries.

by

FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS. FIRTH & JOHN BROWN LIMITED SHEFFIELD · ENGLAND


REMOTE HANDLING EQUIPMENT
FOR RADIOACTIVE AND TOXIC MATERIALS
SAVAGE AND PARSONS LIMITED

nucleol

radiation resistant lubricants for the atomic age

A range developed and perfected by Wakefield-Dick Research

Conventional oils cannot live in conditions of atomic radiation. Such conditions are inseparable from certain parts of any mechanism designed to produce power from nuclear fission.

This, and other allied lubrication problems, was the challenge which faced oil technologists everywhere. And, as so often in the past, Wakefield-Dick's research team produced the answer. An entirely new series of oils and greases, resistant to radiation and named "Nucleol", is now available to lubricate the wheels of this Atomic Age.

A Wakefield-Dick research chemist investigating the effects of radiation on lubricants.

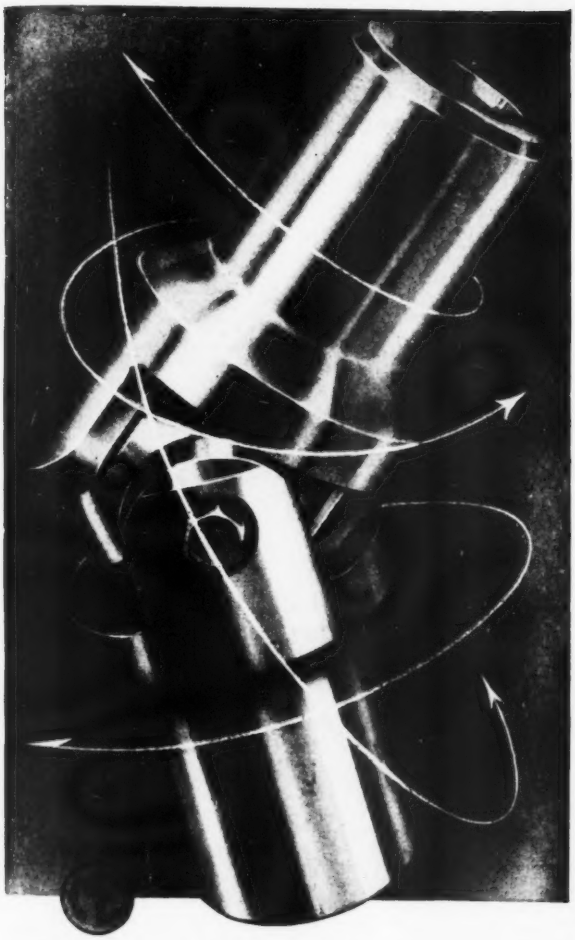
Two examples of the NUCLEOL range

NUCLEOL 522 A radiation resistant lubricant based on selected mineral oils of high aromaticity and containing special inhibitors.

NUCLEOL G 114 A grease gelled with a new compound, and specially inhibited. Designed for the lubrication of control actuator bearings operating at the lower radiation levels.

Tick **No 61** on reply card for further details

Tick **No 62** on reply card for further details



angular motion faithfully transmitted

Light Series Universal Joints are available in special designs for aircraft use, made in light alloy to Spec. L.40 anodised, with hardened ground steel trunnion pins, cadmium plated. They are designed with shank diameters to suit bore of standard aircraft tube and will withstand moderate tension or compression loads. Made in a wide range of sizes, they can be supplied with covers as required.

Patent Universal ball Joint combines high load capacity, simplicity of design and 92-98% efficiency. (N.P.L. certified.)

Hooke's Type Universal joint is suitable for high speeds and is inexpensive to fit.

Grease Retaining Covers are available for all types and sizes of joints.

Air Ministry Gauge Test House Authority 89755/31

THE MOLLART ENGINEERING CO. LTD.
KINGSTON BY-PASS · SURBITON · SURREY · ENGLAND
TELEPHONE: ELMBRIDGE 0033-7 (5 lines) *TELEGRAMS:* PRECISION, SURBITON

SIR! LETTERS TO NUCLEAR POWER

The Editor welcomes correspondence for publication

Flux for prestige

From the Project Leader, Jason Reactor, and Senior Physicist, Hawker Siddeley Nuclear Power Co. Ltd.

SIR : Marvin Fox (*Sir,* June) rightly deplores the indiscriminate purchasing of laboratory reactors, especially when the acquisition is merely for prestige purposes, but I suspect that he may unwittingly start an even worse trend - flux for prestige purposes. It is not necessarily true that 'anything which can be accomplished at low flux levels can be done much easier and faster at higher flux levels' and to say that 'marginal or tough problems can only be done with higher flux levels' gets us nowhere since, presumably, 'marginal' or 'tough' problems are here defined as those which can only be done with higher flux levels !

Is it suggested that the excellent work performed in Chalk Rivers' Zeep (flux 10^8 n/cm^2/sec) would have been better performed in NRU (flux 10^{14} n/cm^2/sec) or that the present programme for Hanford's TTR should be transferred to the Plutonium Production Reactors ?

No, the essential thing is that the reactor should be suitable for the research programme envisaged and should be flexible enough to accommodate day-to-day changes in this programme. I agree with Marvin Fox that those who are in the market for laboratory reactors should consider very carefully what it is they wish to do with them, but I would go further and suggest that they should think twice before throwing away money and effort on running reactors at a higher power than is necessary.

LANGLEY, BUCKS COLIN HUGHES

Recognition for tanks?

Sir : Marvin Fox (Sir ! May) has, I think, pinpointed the essential difference between a pool reactor and a tank reactor (he said in effect that if the only top shield is water it is a pool : if not, it is a tank. *Ed)* This is an important point of nomenclature which, I feel, the British Standards Institution could well take up. In their latest draft 'Glossary of Terms used in Nuclear Science' their definition of 'swimming pool reactor' does not make Dr Fox's distinction and the term 'tank reactor' is not included at all. Furthermore, why include the term 'high-flux' reactor without defining high in this connexion ?

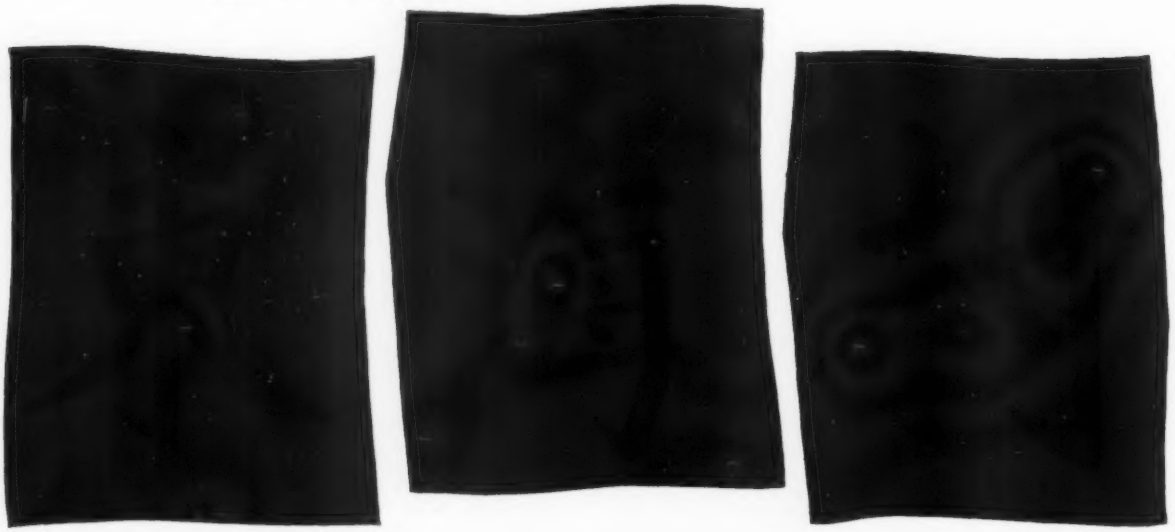
I was also interested to note in the BSI draft that the term 'Uncertainty Principle' is now deprecated in favour of 'Indeterminacy Principle'. Could it be that the modern scientist is ashamed to be uncertain of anything ?

CAMBRIDGE J.P. BRAITHWAITE

TOKAI-MURA

At Tokai-Mura, 70 miles north-east of Tokyo, The General Electric Company Limited of England is to build Japan's first nuclear power station. This 150 MW station will be powered by a single gas-cooled graphite-moderated reactor of the same basic type as the two which are being built by G.E.C. at Hunterston in Scotland. In producing a design to ensure the safety of the installation even under severe earthquake conditions, G.E.C. and her associate Simon-Carves Ltd., have brought to bear the results of much experimental work. For example, models of the pressure vessel mounted on a supporting skirt were subjected to horizontal loads such as would arise from earthquake shock.

Unique protective devices will be provided capable of effective operation even if the core should be severely damaged and tilted to an angle of 45°. In addition to the normal control rod system there is a unique arrangement of boron steel balls which would be released into the channels in the core by seismic pick-ups outside the station or by displacement of the pressure vessel, the core itself, the grid or various other critical parts of the reactor. The station is expected to be in full operation in 1963.



G.E.C. OF ENGLAND

ATOMIC ENERGY DIVISION

320

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND, ERITH, KENT

Nuclear Power
REACTORS MATERIALS INSTRUMENTATION PROCESSES IRRADIATION

JULY 1959 VOLUME 4 NUMBER 39

Nuclear Initiative

SEVEN British firms have put forward realistic proposals for ship reactors. Taking into account the power station consortia and the companies which are known to be in the reactor business but who have not responded to the Galbraith invitation, there are now at least twelve firms with sufficient resources to design and manufacture reactors of one kind or another. Several are linked in various ways with United States firms, but in the case of the pressurized or boiling water reactors, for example, there is little point in going it absolutely alone when there is such a volume of practical experience on the other side of the Atlantic.

This situation is very encouraging. It shows that the nuclear industry is now emerging from its apprenticeship phase and is in fact rapidly seizing the initiative. Up till now reactor development in this country has been firmly and, on the whole, wisely guided along the gas-cooled path by the Atomic Energy Authority, and firms which have been lucky enough to share in this have had an invaluable period of training. No one in their senses would claim that all the problems of the natural uranium reactor have been solved. But it has been apparent for some time that the first-class design teams in the gas-cooled groups have been able to devote some time to other types of reactors. Even the firms which are not in the consortium business have accumulated a good deal of reactor knowhow, either through AEA development contracts or by US agreements and their ship proposals must be regarded most seriously.

A successful ship reactor must not, however, be regarded as an end in itself. The time has come when the development of an economic land-based reactor in the smaller power range - less than 50MW - is a matter of urgency. This is not only to meet the peak load problem which will arise in our own power networks by about 1965, but also for export. While it does not follow that a land-based plant can be successfully adapted for marine use, the reverse is almost certainly true. Thus there is a double incentive for us to push on with these smaller reactors as quickly as possible. That they will all need some enrichment is obvious, but where the fuel is to come from is not. This is largely a political problem and it must be tackled energetically now or we shall live to regret it. It is all very well talking about plutonium, but even the Americans have not mastered the techniques of using this yet. It would be simpler for us to work with U-235 for a start because there is so much more experience available.

The Government's plans for the ship reactor are vague. Apparently the intention is to instal a reactor in a fleet tanker and the Galbraith Committee's task is to select what they consider the most promising type. This is a horribly difficult job and whatever they do they are bound to bring down criticism. From a purely technical point of view one would like to see all the proposals given an opportunity of demonstrating feasibility. Few if any of the firms would be capable of mounting a demonstration at their own expense, as has been done in the US by one or two giants, but some might be prepared to go part of the way if other backing was forthcoming. For example, the time has probably come when a realistic proposal could be put to one of the large oil tanker firms for a purely commercial demonstration.

The pace of nuclear development is now outstripping governments, both here and abroad. Subject at all times to considerations of public safety, we welcome this as a perfectly natural and desirable development.

RIO TINTO

is now able to supply uranium in commercial quantities for power and research programmes. The nuclear grade products now available include the following:

Ammonium Diuranate	Uranyl Nitrate Hexahydrate
Standard Grade Uranium Dioxide	Ceramic Grade Uranium Dioxide
Uranium Tetrafluoride	Uranium Metal

Uranium metal is normally supplied as machined ingot but facilities exist for forging and rolling to special sizes and shapes to meet individual requirements.

Prices and specifications on application to
Rio Tinto Management Services (UK) Limited
Barrington House, 59 Gresham Street, London, E.C.2
TELEPHONE: METROPOLITAN 9101

Worldview

the month in atomic energy

APC get Trawsfynydd

In the middle of June, the Central Electricity Generating Board issued a letter of intent to Atomic Power Constructions Ltd. (APC), for a 500MW gas-cooled, graphite-moderated nuclear power station at Trawsfynydd, in North Wales. Formed at the end of 1956, APC is the last of the UK consortia to receive a contract for one of the 'first generation' nuclear power stations. This project is estimated to cost some £M60 and is scheduled to come into operation during 1964.

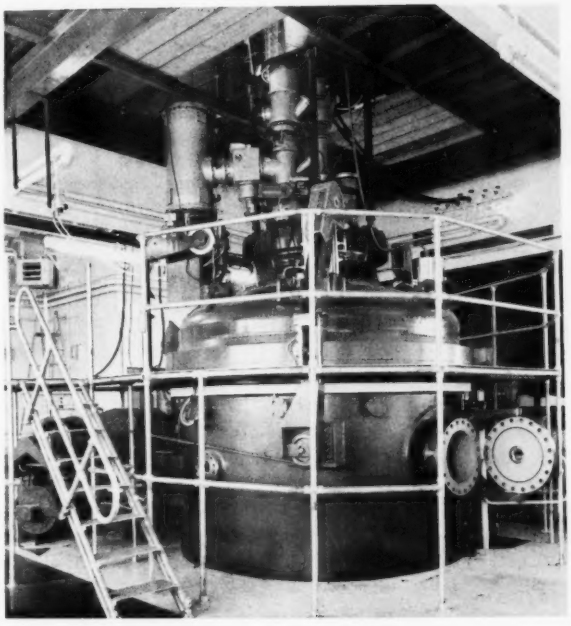
Each of the two 61ft. internal diameter reactors, of 3½ in. thick plate, feed six boilers which provide a dual pressure steam cycle for the generating plant. A feature of the design is that the CO_2 is circulated by a constant speed drive, with one circulator to each boiler. Working at a nominal pressure of 240 lb/sq in., CO_2 enters the reactor at approximately 200°C and is passed to the boilers at nearly 400°C. Control is effected by a by-pass system for each blower, as well as isolating valves.

Of the steam flow, 65% is h.p. at 927 lb/sq in. and 380°C, and 35% is l.p. at 290 lb/sq in. and 364°C for the turbogenerators, each having a maximum continuous rating of 145 MW. APC will be responsible for the overall design, construction and commissioning of the station, with member companies supplying specialized equipment. International Combustion will fabricate the boilers, CO_2 ducting and biological shield cooling system. Fairey Aviation equipment includes burst fuel element detection gear, control rod mechanism, charge machines and graphite machining. Richardsons, Westgarth will make the circulators, dump condensing plant and turboalternator sets. Crompton Parkinson will supply electrical items, including main and auxiliary transformers. The two reactor vessels and a 400-ton Goliath crane will be fabricated by Babcock & Wilcox, with Nuclear Civil Constructors - a partnership of Trollope & Colls Ltd., Holland & Hannen and Cubitts Ltd. - carrying out the civil engineering work.

A-sub keel laid

At the Barrow-in-Furness yard of Vickers-Armstrongs on June 12, Prince Philip 'laid the keel' of the Royal Navy's first nuclear submarine, HMS 'Dreadnought'. The ship actually has no keel in the accepted sense so the ceremony consisted of the Prince's fixing a commemorative plaque on to a small section of her hull by means of explosive bolt guns. Before he did this he opened a Cs-137 source shutter which activated a gamma switch. This started a winch which pulled the section on its trolley alongside the royal dais.

No further information on the submarine was released. It will, however, probably be very similar indeed to USS 'Skipjack' (2700 tons, 252 ft overall) and it will be powered by a Westinghouse S5W pressurized water reactor. Westinghouse are to supply the complete set of propulsion machinery for the submarine and also full design and manufacture information to enable Rolls-Royce to build further reactors. The hull is apparently to be largely British-designed by Vickers-Armstrongs but they are to obtain full information on 'Skipjack' from the Electric Boat Division of General Dynamics.



AWRE's LATEST MACHINE. The pressure vessel for the 12 MeV tandem Van de Graaff is 45ft high and 9ft dia. It contains nitrogen and carbon dioxide at 200 lb/sq. in. Seen here is the top end with the lower part of the ion source. Note open manhole on right

Rowse Muir Publications Ltd announce that Mr. John Woodeson has been appointed Editor of NUCLEAR POWER with effect from June 22. Mr. Caldwell Davidson, who relinquishes the editorial chair, becomes Group Director in charge of editorial planning and coordination of both Rowse Muir magazines, CONTROL and NUCLEAR POWER, and also research on new projects.

An artist's impression of the 'Dreadnought's' layout (see 'A-sub keel laid', this page) shows: 1, Hydroplane; 2, Torpedo tubes; 3, Torpedo compartment; 4, O ficers' accommodation; 5, Crew's quarters; 6, Stores; 7, Pump room; 8, Control compartment; 9, Captain's accommodation; 10, Washplaces; 11, Galley; 12, Battery compartment; 13, Reactor; 14, Machinery control compartment; 15, Main machinery compartments; 16, Turbine gearing; 17, Propulsion motor

No cost has been disclosed for 'Dreadnought' but the bill for 'Skipjack' was about $M60.

Prince Philip referred to 'the astonishing achievements of the US Navy's nuclear powered submarines' and said that as a result of this new collaboration we should have one in a reasonable time for the price of one set of machinery without having to divert any of our limited number of nuclear scientists and engineers from their vital work in fundamental research and the nuclear power programme.

Earlier, Vickers-Armstrongs chairman Major-General Sir Charles Dunphie explained that just as the ship itself would be unconventional, so the method of building will be different. A hint that 'Dreadnought' would be ready far quicker than is commonly supposed came from First Lord of the Admiralty, Lord Selkirk. He said he was confident that many people would be surprised at the short time it will take to put this ship into the water. This was generally interpreted to mean some time in 1960.

AWRE's new machine

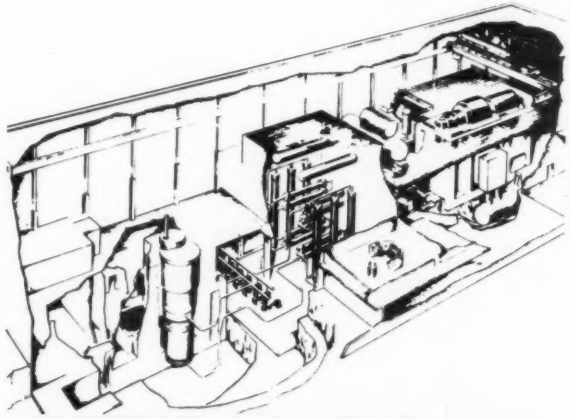
A 13 MeV tandem electrostatic generator of the Van de Graff type was recently put into operation at the Atomic Weapons Research Establishment, Aldermaston. Designed by a joint Aldermaston, Harwell, Metropolitan-Vickers team and built by Metrovick, the machine has an identical twin at Harwell. It is part of the AWRE's Nuclear Physics Research Division which is now situated in an enclave within the classified area of the establishment. Other major equipment includes 6 MeV and 3 MeV Van de Graaffs by High Voltage Corporation and an 800 kV Cockcroft-Walton generator by Philips Electrical.

Introducing the tandem machine to newspapermen recently, Dr. K.W. Allen, Senior Superintendent of Nuclear Research said it would open up a new range of particle energies which at present was largely unexplored. He said the principle of the tandem was first enunciated over 25 years ago in the United States by Willard Bennett. In 1955 it was taken up in a practical way by High Voltage Corporation who had recently supplied a horizontal model to Chalk River. Aldermaston's machine was, however, a purely British effort. It had already worked successfully at 10·3 MeV and it was expected that it would reach 11-12 MeV in the near future. The cost of the machine, excluding design, was about £200,000.

The principle of the tandem machine is ingenious. The bottom half of the column consists of a normal Van de Graaff which raises the potential of the centre point to 6 MeV. At the top of the column negative ions are injected which accelerate to the centre point at a potential of 6 MeV. Here, they pass through a stripper consisting of a tube containing gas at low pressure. This removes electrons from the ions, transforming them to positive ions which then continue accelerating down the tube to earth potential, thus acquiring a total energy of 12 MeV.

Several interesting pieces of research apparatus are being built to go with the tandem machine, including a multi-channel particle spectrometer. This will expose 24 plates and cover simultaneously an angular range of 5^{o} to 175^{o}. The 13-ton, 12000-gauss magnet is contained in a welded aluminium vessel 8½ft dia. by 9ft high containing a vacuum of 10^{-4} to 10^{-5} mm. Another new piece of apparatus is a very large liquid scintillation counter using 12 p/m tubes surrounding the spherical vessel. It will be used for measuring fission yields using fission chambers. Incidentally, Aldermaston workers using an earlier scintillation counter in conjunction with their 6 MeV Van de Graaff have established a value for U-235 fission yield for 75kV neutrons some 6½% lower than the generally accepted figure.

Speaking to the newspapermen, Sir William Penney, AEA member for Research and former Aldermaston Director, outlined some of the 'peaceful' work of the establishment. In answer to a question, he stated that about 10% of their effort came into this category. In particular, the AWRE had recently completed several plutonium fuel plates (20% pu, 80% Al, by weight).



THE CANADIAN OCDRE PROJECT. Layout of the organic-cooled heavy water-moderated design shows l. to r. the reactor, heat exchangers, turbine and electricity generating gear. (See 'Trying to reduce nuclear power costs')

More marine proposals

English Electric have completed a preliminary survey of possible reactor systems for the economic propulsion of merchant ships which has been carried out for and in consultation with the shipbuilders, Vickers-Armstrongs. The study took almost a year and took into account alternative forms of propulsion, both oil and nuclear, for various types of vessel. Detailed evaluation was made of a small number of systems which showed commercial promise.

Although English Electric did not submit design proposals to the recent Galbraith Committee exhibition, they have passed their figures to the Admiralty and have recommended that these would provide a basis for more detailed work in a narrower field as more information becomes available from sources within the English Electric Group - this must to a big extent be based on their recent tie-up with Atomics International. If the Galbraith Committee await this information, they may well find themselves faced with several additional proposals as at least three large companies in the North of England are accelerating their efforts to achieve economic nuclear marine propulsion.

INTERNATIONAL

Dragon plans and changes

The first meeting of the International Board of Management of the OEEC's 'Dragon' project was held at Winfrith on June 1. The broad programme of work drawn up by the General Purpose Committee, under Dr. J. Gueron of Euratom, was approved and the appointment of Mr. C.A. Rennie, of AERE Harwell, as Chief Executive of the project was confirmed. As from July 1, the Vice-Chairman of the Board of Management will be Sir William Penney in place of Sir John Cockcroft.

US-Euratom plans mount up

On June 1, the US-Euratom Joint Research & Development Board announced that over 200 proposals to participate in the joint reactor research and development programme had been received. The total amount involved in definitive proposals is approximately $M37 and more is expected as the programme develops. A breakdown shows that some 25 American, 17 Belgian, 3 Dutch, 26 French, 4 German and 8 Italian companies and organisations are interested in taking part in, amongst other things, the building of American-type reactors of some 1000MW total capacity within the next four to six years.

OEEC comes to UK for advice

At the instigation of OEEC, Eurochemic will be formally inaugurated in July and will begin its work of setting up, and later operating, a reprocessing plant for spent nuclear fuel in Mol in Belgium. In the meantime, the interim organization has appointed W.J. Frazer & Co. Ltd., of Romford, as the consulting engineers on the treatment, containment and disposal of all radioactive effluents from the new processing plant. Advice from the UK Atomic Energy Authority will be available to Frasers.

British firm learns more about OMRs

An agreement providing for mutual technical assistance in the field of organic-moderated reactors was reached at the end of May between Atomics International and the English Electric Co. Ltd. It provides for the manufacture of reactor and components by both companies, the exchange of technical advisory services and the training of English Electric personnel in the technology of OMRs.

At the present time, it is envisaged that this agreement will not affect the English Electric arrangements with Babcock & Wilcox, which are limited to gas-cooled, graphite-moderated reactors of over 150MW electrical output.

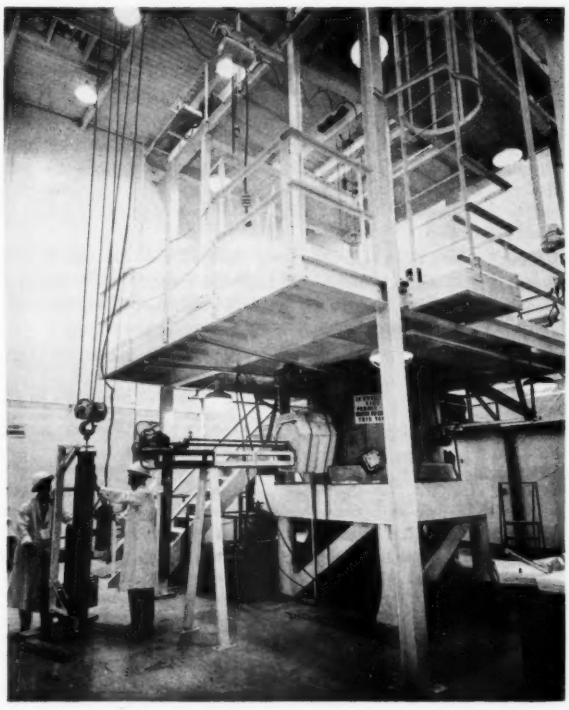
Germans buy UK know-how

The General Electric Co. has signed a long-term agreement with Maschinenfabrik Augsburg-Nurnberg AG (MAN). Initially for ten years, but capable of extension, it covers the payment of a capital sum plus a service fee per kw of guaranteed electrical output from nuclear power stations ordered from MAN and is based on all types of GEC gas-cooled, graphite-moderated reactors, including ship-propulsion units. Patents and 'know-how' will be exchanged between the two companies, but in the early stages GEC will act as the main contractor for all nuclear orders received by MAN ; ultimately the German company will carry out complete contracts on its own and has already supplied heat exchangers and structural items for the Australian Hifar reactor at Lucas Heights.

CANADA

G E to design OCDRE

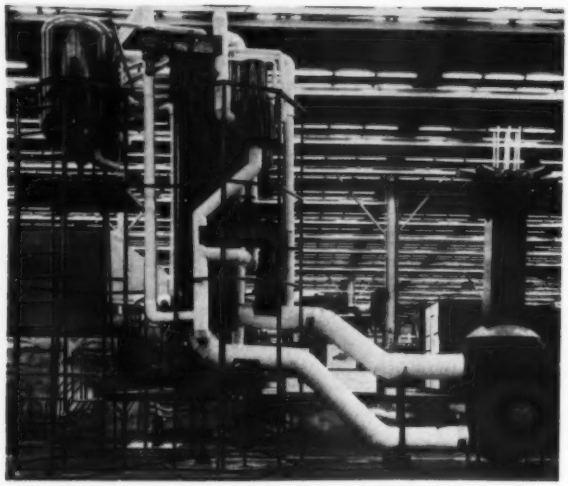
A contract, valued at $600,000, has been awarded to Canadian General Electric Co. Ltd. by Atomic Energy of Canada Ltd. for a reactor design study and development. The reactor, known as OCDRE (Organic-cooled, Deuterium-moderated Reactor Experiment) will burn natural uranium and will be used to investigate methods of reducing capital costs without allowing running costs to reach a prohibitive level. Organic cooling not only reduces the coolant costs from $28 to about 40 cents when compared with heavy water, but because of higher boiling points, enables a low pressure system to be used, and with these less corrosive liquids, more conventional materials may be used in the construction. It is anticipated that the eventual application of this project will be for small and medium size plants, including generating stations for use under Arctic conditions.



US INDUSTRY'S OWN FACILITY. Atomics International's organic-moderated reactor, in the Santa Susana Mts., 30 miles NW of Los Angeles, went critical in June

Firsts in nuclear fuelling

During June, Canadian industry achieved two 'firsts' in nuclear fuelling. The world's first installation to recover thorium from the waste liquors in uranium milling has gone into production. This



MOCK-UP OF LOCKHEED'S PORTABLE REACTOR. Designed to produce 1MW of electricity and 7M B.Th.U. of heat per hour, this 150 ton unit will use enriched uranium fuel

is at Elliot Lake, Ontario, and was built in six months by Humphreys & Glasgow (Canada) Ltd. for Rio Tinto Dow Ltd. at a cost of some $M1. In the process used - solvent extraction - approximately half a pound of thorium can be recovered for each pound of uranium produced.

AMF Atomics (Canada) Ltd. have exported the first reactor fuel elements from Canada - the 290, fifty-four pound, aluminium-clad uranium rods, valued at nearly $400,000, were shipped by air to Diorit research reactor, near Zurich.

CZECHOSLOVAKIA

USSR builds reactor vessel

The 150MW heavy water-moderated, gas-cooled reactor at Bohunice, Slovakia, for the Czech Ministry of Power and Water Economy, is now well under way. The reactor vessel, some 62ft high and over 16ft in diameter, has been built in the USSR to a joint Czech-Soviet design and will contain 156 natural uranium fuel elements and 40 control rods. The boilers for this unit employ unusually thin plain-walled tubing and the method of locating them in the boilers has already interested members of the Swedish State Power Board.

UNITED STATES

Cheaper isotopes

With effect from June 1, the AEC has reduced the prices of a number of isotopes produced and distributed by the Commission's Oak Ridge National Laboratory. By far the most important ; carbon-14, which used to cost between $22 and $28 per millicurie depending on quantity, is now down to $13. Other materials affected by these changes are chlorine-36, thallium-204, iridium-192 and iron-59. Certain of the less commonly used radioisotopes, such as sodium-24 and yttrium-90, have been slightly increased in price.

More reactor contracts

The AEC has signed a cost-plus-fixed-fee contract with the Martin Co., Baltimore, to design, develop, construct, and install a factory assembled, pressurized water reactor, PM-1, cooled and moderated by light water and fuelled with highly enriched uranium. Output will be 1MW electrical and 2MW thermal. It will be built in units suitable for air transportation and is one of a family of such plants being developed for the US armed forces.

The Walter Reed Army Medical Centre in Washington, DC, is to have a 50MW reactor for biological research and medical treatment. It is an Atomics International Model, using uranyl sulphate solution highly enriched with uranium-235, and a unique feature will be an area below the reactor where experiments may be conducted with a high intensity source of gamma rays essentially free of neutrons. It will be put into operation in about a year's time.

WORLD BRIEFS

AUSTRALIA. Research grants totalling nearly £28,000 have been awarded by the Australian AEC to support research in seven Australian universities and will support the Commission's own work in developing civilian uses of atomic energy.

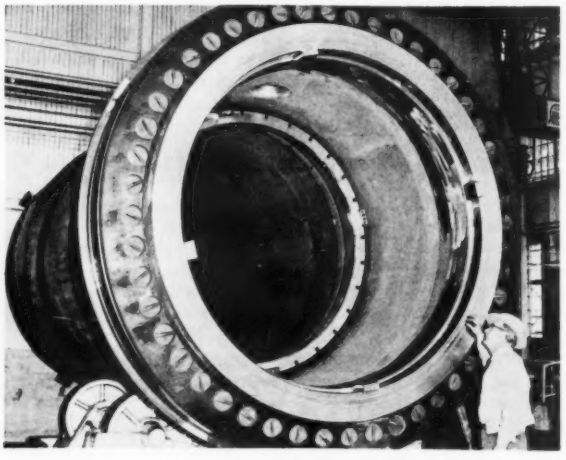
BRAZIL. An Executive Group for the Application of Electronic Computers (GEACE) has been established whose main function will be to promote and supervise centres for the preparation of data and the assembly or manufacture of computers and their components.

FRANCE. CEA are setting up their fourth Centre of Nuclear Studies at Cadarache, situated at the junction of the Durance and Verdon rivers. It will be mainly used for experimental studies on various types of reactors, fuel behaviour and structural materials.

ISRAEL. An AMF research and training reactor is now being installed at the Israeli Atomic Energy Commission's establishment south of Tel Aviv. Initially it will work at 1MW thermal level when it goes into operation early next year, but will be subsequently stepped up to 5MW thermal.

ITALY. Prof. Tommaso Zerbi has been appointed chairman of SENN, in place of Ing. Carlo Matteini who resigned in April.

UNITED STATES. To coordinate reactor programmes a new division has been established by the AEC at Oak Ridge. The new Reactor Division will be directed by Dr. D.F. Cope.



N S SAVANNAH'S' REACTOR VESSEL. After taking over a year to make, it has now been installed at the Camden, New Jersey, shipyards, and the ship will be christened by Mrs. Eisenhower on July 21

Five hundred European engineers and industrialists met recently to consider ways and means of achieving a programme for 8500 MW nuclear by 1965

Europe's master plan
— a report on the Stresa Conference

by CALDWELL DAVIDSON

In terms of sheer megawatts, Europe's target for nuclear power is now 8500 by the end of 1965. Of this, 4500MW will come from the UK's gas-cooled graphite-moderated reactors and the remainder from the initial 1000MW US-Euratom joint programme, together with other national and international projects. Natural uranium reactors will account for 6000MW and enriched types for 2500MW. At the end of 1965 the annual rate of growth is estimated to be 2500MW.

Such is the framework round which was built the European Nuclear Energy Agency's Stresa Conference for Industrial Management (May 11-14). These estimates were prepared by an Agency working party headed by Aldo Forcella, head of Italy's CNRN Reactor Division, and including technical and economic experts from most OEEC countries and the US. From this basic premise, other working committees were able to make forecasts of the quantities of fuel, special materials, and engineering plant that will be required to meet the programme. Other committees went into the problems of finance and of national legislation. The assumptions made regarding the two broad classes of reactor are given in Table II.

	Natural uranium	Enriched uranium
Gas-cooled, graphite moderated (UK, France, Italy etc.)	5500	
Gas-cooled, D_2O moderated (Sweden)	300	
D_2O moderated and cooled	200	
Pressurized water (Euratom)		1000
Boiling water (Euratom)		1000
Organic moderated and cooled (Euratom)		500
	6000	2500

Table I — Europe's power programme by 1965

Annual consumption of uranium in plants working by 1965 is estimated to be about 1700 tons natural plus 200 tons of enriched (4 tons of U-235). However, taking into account pipeline requirements and an annual amount for initial loadings of new reactors, the gross requirements in 1965 come to about 5000 tons of natural uranium and 500 tons of 2%-enriched. The actual amounts may be less than this since it is difficult to know just how much recycling may be done by 1965 but the ENEA believe that by this means the 500 tons of enriched uranium might be reduced to about 400 tons.

What is this going to cost ? Uranium has now become one of the main mining products of the free world and the 1958 production of 34,000 short tons of U308 was worth about $M800 . Of the 5000 tons of natural needed in Europe by 1965, 3500 tons will probably go to the UK from Commonwealth sources, the balance of 1500 tons coming from indigenous European sources (France, principally). In the United States the annual demand for uranium is expected to reach 27,500 tons in 1960. About 20,000 tons of this will probably go to the three diffusion plants and the remainder to the Hanford and Savannah River plutonium plants. The British diffusion plant at Capenhurst and the French one at Pierrelatte between them are expected to absorb 1000-2000 tons of natural uranium per year.

Cost of uranium falling

Price of uranium concentrates and metal is tending to fall fairly rapidly. Prices now range between $10-12 per lb of U_3O_8 but by 1962 the price for concentrates should have flattened out at $8 /lb. Reduced natural metal is expected to be nearer $30 than $40 per kg. For the 2% enriched material, costs can only be based on the present American price, which is $220/kg, corresponding to $11/g of contained U-235.

Costs of fabrication into elements vary widely with the form and the cladding but the ENEA have taken $16/kg for natural elements, which corresponds with the British price. As to enriched elements, the US-Euratom agreement guarantees a manufacturing price from hexafluoride of not more than $100 per kg of U-content for stainless-steel-clad dioxide elements and $140 per kg of U-content for zirconium sheathing. The ENEA, unable to decide how many reactors would use stainless steel and how many zirconium, settled on an average manufactured cost for 2%-enriched elements of $120/kg.

After allowing $20/kg for reprocessing for both natural and enriched uranium and a credit of $10-15/kg for natural and $120/kg for enriched uranium, the Agency estimates that Europe's net annual fuel bill at the end of 1965 should be about $M400 a year. Only a little of the natural uranium requirements will have to be paid for in US dollars, but it is assumed that virtually all

the enriched fuel will come from America. Manufacture of elements is however assumed to be done wholly in Europe. On this basis it is believed that US dollar expenditure will be $M30-40 for natural uranium and $M85 for enriched uranium.

	Natural uranium	Enriched uranium
Enrichment		2%
Burnup	3000 MWd/t	10,000 MWd/t
Load factor	75%	75%
Thermal efficiency	27%	27%
Sp. power	0·7 MW(e)/t	0·25 MW(e)/kg U.235

Table II — ENEA's basic assumptions for reactors

As to capital costs, ENEA see natural uranium power stations dropping from $400 to $300 per kilowatt during the period 1960-65. During the same period, enriched plants will drop from $350 to $280. Taking average values, the cumulative investment cost of the 8500MW 1965 programme is about $M3000, the annual investment then running at about $M750. It is believed that natural uranium reactors will be built wholly by European industry but that about 20% of the enriched reactor programme will have to be paid for in US dollars. This means a cumulative gain to the US of $M160 with an annual income of the order of $M40 by 1965.

Graphite demands can be met

Graphite requirements for this programme are fairly easy to estimate since the bulk will be needed in Britain and France, both of which have well-defined programmes. Total capacity of graphite-moderated power reactors in Europe by 1965 should be in the region of 5500MW. This will need about 80,000 tons of machined blocks, or about 150,000 tons of unfinished material. At this date, to meet the annual installation rate of this type of reactor at that time, production capacity of unfinished nuclear grade graphite would have to be about 40,000 tons a year. Compared with this, the demand for graphite for research reactors is considered 'insignificant'. By this time impermeable graphite might be needed for fuel cladding in high temperature reactors but the amounts needed are not considered important.

The Agency experts consider that existing production facilities in the UK, France and Germany should be quite capable of meeting this demand. Present-day prices for unworked nuclear grade are in the range $1-1·25 per kg. Using these figures the investment in graphite by 1965 should be about $M150 and it will be running at about $M40 a year.

Having visualized this overall programme, the Agency then examined what would be required in manufactured special equipment. This was done by a committee headed by Robert Gibrat of Indatom (France) and covered pumps, valves, blowers, turbines, heat exchangers, reactor vessels, gas scrubbing and filtering appliances, shielding, pipework, hot fuel handling plant, equipment for a gas diffusion plant, and fuel elements themselves. The general conclusion of the study is, in M. Gibrat's words, that 'the production programmes arising out of the European programme for the period 1959-1965 do not involve any quantitative difficulties for European industry and although the latter is still relatively a newcomer where nuclear energy is concerned, it feels quite prepared to solve the best part of the qualitative problems involved.'

Slackening in urgency

The conference itself showed a very marked contrast in tone with previous international gatherings of this kind. As Prof. Otto Löbl (Germany), adviser to RWE, remarked, the first wave of enthusiasm had abated and more sober assessments were necessary. Nevertheless it was generally conceded that the 4000MW-by-1965 programme for Europe (excluding the UK) is realistic. It is not big enough to strain unduly the financial and technical resources available but it should enable all the worthwhile reactor types to be investigated and give valuable design, manufacturing and operating experience. The principal factor leading to the slackening in urgency is, of course, the very much improved fossil fuel position generally, and the threatened power famine now seems a little more remote. Dr. Boettcher of Degussa, for example, said there was no fuel emergency in Germany and her basic idea on nuclear power at the moment was not kilowatts but as wide experience as possible. Thus Germany's plans for 1965 were based on about 500MW, to be obtained from a British type reactor, the Krupp-BBC potato heap, a PWR, a BWR and an OMR. France, too, is planning no crash programme and a speaker said that recent oil and natural gas strikes in French Equatorial Africa had completely altered the situation. Electricité de France was thus in a good position and intended to switch to nuclear power only very gradually by building a progressive series of nuclear plants which he described as full-size models. Speaking for Italy, SELNI president Giorgio Valerio said there was still a great lack of actual experience and forecasts must be regarded with great care. Nevertheless, he believed that the future certainly belonged to nuclear energy and declared that the comparatively high cost of the first stations must be put down on the progress expense account. From the US, Atomics International's Chauncey Starr reminded delegates that the nuclear business was still in its infancy but that, given another five years' development at this rate, power reactors would be fully economic in Europe, if not in the US.

Nuclear stations a 'public duty' ?

One of the most interesting contributions was from Manuel Gutierrez Cortines, executive vice-president of Nuclenor, the nuclear power group centred at Santander, Spain. Señor Cortines claimed that nuclear plants had so far, except in Britain, been bought not because they were really needed as part of a supply system but because the utilities considered it part of their public duty to contribute to the development of the new technique which, he declared 'appears to be the only way of solving the problem of meeting the demand for electricity in the not too distant future (i.e. mid-60's).' He said Nuclenor was planning a 2-reactor 500MW station and so was another Spanish group. Both considered a 200MW(e) reactor the minimum economic size for their

networks and he thought that what was true for Spain was probably true for most of Europe. Not all the delegates would, however, agree with this.

There is certainly now no stampede by the Europeans to instal nuclear power stations and when they do they want to do as much of the work themselves as is humanly possible. At the same time it is recognized that atomic energy will be needed and that a start must be made now in order to gain experience. What most countries would like now is a small power reactor or two which they could play around with before sinking a vast amount into a full-scale plant. This, of course, is just what the Germans are doing with the 15MW Kahl BWR. On the other hand the Italians have taken the plunge with two full-scale plants and there is little doubt that when Spain does, this will also be on the full-scale - probably with a British reactor.

Still no 'best' reactor type

There is as yet no sign of the 'conventional' nuclear power plant emerging from the welter of reactor types now in project. Indeed the Stresa air was quite loud with the sounds of axe-grinding. Chauncey Starr thought it would be ten years yet before we knew for certain we had the best type : it would be decided, he maintained, not so much by economics as by the simplicity, safety and reliability of operation - by what sort of men you would need to staff it.

Starr said we should not be obsessed by the idea of high temperature reactors, but it was our opinion he received little support for this view. Senor Cortines, for example, said that due to the present low temperatures available the conventional parts of a nuclear power station - turbines, condensers, circulating pumps - would be considered obsolete in a conventional power station of today. The poor quality steam meant units of great size and cost and of low thermal efficiency. This often led to siting difficulties, due either to transport problems, cooling water demands, or both. Cortines' view was supported by Sir William Cook (AEA) who claimed that, due to their having to use saturated steam, the turbines for the Dresden and SENN boiling water reactors are physically amongst the largest units ever built. It seems that there is a case to be made out in certain circumstances for auxiliary oil - or coal - fired superheating but most delegates agree that for the long-term, nuclear superheating was what is needed.

An interesting divergence of views on the temperature question was apparent in the contribution of two British speakers. W.R. Wootton of Babcock & Wilcox said the main reason for high capital costs was the fact that temperatures were too low. This made everything very big. While he saw little prospect of gas turbines temperatures (650°C) in the foreseable future, he wanted to get 550°C steam. Roger Vaughan of the NPPCo, on the other hand, said that high temperatures cost money and that we should concentrate on improved heat transfer and better pressure circuits for the present. Incidentally, he thought that capital costs might be cut by as much as 15% in the gas-cooled design by going for a larger number of factory-assembled heat exchangers as the French have done for EDF-1. He mentioned that site fabrication of the British type of steam-raising unit had proved difficult and this might be a pointer to a new approach at NPPCo.

Cost in cutting, the 'leit motif'

The theme of cost reduction ran like a leit-motif through the whole conference, and while everyone agreed it could be done opinions varied as to the method. Chauncey Starr, for example, said that 2/3 of the capital cost of a complete plant was in non-nuclear components and he did not see how this could be reduced much. He was, of course, assuming that there would be no very significant rise in temperature for some time. Several speakers mentioned the factor of 'overdesign'. Myron C. Beekman of Detroit Edison (Enrico Fermi fast breeder), for example, said that in the present state of the art a very conservative approach was necessary but as successive plants were completed it should be possible to do without many things which we at present deem essential - austenitic steels, for instance.

The point was taken up by Edgard Demierbe (Belgium) director of ACEC's nuclear division who demonstrated in the case of the ACEC Westinghouse PWR how this could be done in three successive models. All reactors are basically the same but each one had its output stepped up, its tolerances widened, and its safety factors cut progressively where possible. As examples of paring Demierbe cited : reductions in numbers of valves and pumps, fewer instrumentation channels, cheaper materials and general increase in knowhow.

Capital cost in $M	170MW	190MW	210MW
Nuclear			
civil engineering	3	3	3
containment	2	1·5	1·0
pressure vessel	3	2·5	2
inst. & control	2	1·5	1
heat exchangers	2·5	2	2
pumps	2	1	0·5
valves & pipework	3	2	1
fuel handling	0·5	0·5	0·5
waste disposal	1	1	1
erection	3	2	2
contingencies	2	1·5	1·5
Total nuclear plant	24	18·5	15·5
Non-nuclear plant	14	13	13
Design and development	8	6	4·9
Capital charges	12	9	8
total	58	46·5	40·5
$ per kW	340	245	190
Running cost, mills/kWh			
fixed charges (13%)	7	5	4
fuel costs	4	3·5	3
operating expenses	1	1	1
	12	9·5	8

Table III — Cutting the cost of PWR power (Demierbe)

Advocates of most systems were able to have their say and it was interesting to hear Lew Kowarski, ENEA's Scientific Counsellor, emerge as a BWR enthusiast and his praise of US General Electric's Operation Sunrise project. There appeared to be no enthusi-

asm for anything very complicated and concepts like metal-cooled thermal and homogeneous reactors of various kinds were barely mentioned. Myron Beekman however put over the case for the fast breeder very eloquently and he insisted that Detroit Edison had chosen it because they believed it would prove cheapest. He claimed that the Fermi plant costs had increased less than any other reactor in the US. Its present estimated cost of $M44 amounted to $231/KW with power at 9 mills on 75% load factor. With experience he felt sure these costs could be cut drastically in future plants and indicated how he would do it (e.g. eliminate the secondary loop and its containment). The various heavy water enthusiasts received a lot of attention too, Howieson (Atomic Energy of Canada) remarking that we could not afford to waste neutrons.

Construction problem still considerable

With the reactor construction programme (4000MW by 1965, ex UK) now fairly definite, most of the European industrialists seem to feel that they can handle the actual construction without much trouble in spite of a forceful warning by W.R. Wootton of UK Babcock & Wilcox and also by Chauncey Starr (Atomics International). Starr told delegates 'until you've actually built a plant, you don't realize how complicated it is.' Wootton got down to detail on this theme by presenting a fearsome questionnaire which he would like to put to anyone who thought they could build pressure vessels. J.M. Hill (UKAEA), too, made a point of this, talking about fuel element manufacture. After describing the new plant at Risley, he said the actual design of a new element was the most difficult problem of all. This was partly because it took so long to obtain statistical irradiation experience without which design features couldn't be changed.

General opinion seems to be that, although quantitatively Europe could cope quite easily, nuclear energy was a thing of quality and at the moment there was quite a lot to learn.

Duplication in nucleonics

Sweeping changes in reactor instrumentation were foreshadowed during the panel discussions on this subject. At present the neutron population in the case of a power reactor is deduced by readings of an ion chamber outside the pressure vessel but as reactors get bigger the relationship becomes more inexact and some other method is needed. Flux has to be measured from shut down to 120% full power and no one method can cover the range. Peter Hjertberg (ASEA) said that although temperature could give an accurate indication of output at high power levels there still remained the need for a reliable in-core neutron detector. This seems likely to be a semi-conductor device and the development of a suitable conductivity cell operating on 1-2 volts could transform the whole scene, said Denis Taylor (Plessey Nucleonics) who was chairman of the discussion.

The volume of nucleonics instrumentation remains very small in relation to the total. Siegfried Leisegang (Kernreaktor, Karlsruhe), for example, said that in Germany there were four large instrumentation firms interested in reactors. The 500MW 1965 programme would, in terms of instruments, amount to about $M1·2 a year, whereas the total turnover of these companies is now over $M100 a year. He pointed out however that at present Germany has no producer of neutron detectors, although the next 1 or 2 years should see some available. For France, Bernard de Gaulle of l'Electronique Appliquee said that reactor instruments amounted in value to between 1 and 2% of the total instrument turnover.

It was evident to all that the nucleonic market is never likely to be large in relation to the instrument industry as a whole. The instruments are, however, expensive in themselves and carry a very heavy development charge. The conference was somewhat concerned about signs of wasteful duplication of efforts to compete in this rather narrow market and Denis Taylor put forward a plea for more international cooperation between individual firms in the way of licence agreements.

Value of instruments %	Power reactors	Research reactors
Nucleonic instruments	10	35
Conventional instruments	20	20
Burst slug detection	40	5
Flux scanning	13	-
Control rod actuators	11	25
Health instruments	6	15

note : this does not include data logging and computers nor does it include any graphic panels required

Table IV — Instrumentation costs in power and research reactors (Taylor)

One impression left by the conference is that nuclear energy, once the province of governments, is moving rapidly into the sphere of private and public industry. This was epitomized by Francis McCune, GE vice-president, who said 'I believe industry should lead and not wait for governments.' Acting on this principle, and not even waiting for the US-Euratom umbrella, American firms have moved right in Europe and there now is scarcely a reactor company that has not a network of subsidiaries or licencees on this side of the Atlantic. So far, British firms have been slow to follow but the NPP/AGIP and GEC/MAN agreements are noteworthy efforts and show beyond question that there is a European market for British knowhow. The means certainly exist for an extension of this principle through the UK-Euratom treaty.

There are still many problems of national and international law and of public safety to be solved. Governments and the various international agencies will of course be heavily involved in settling these, but in general it can be said that the practical realization of economic nuclear power is now the responsibility of industry. How this will be brought about will vary somewhat from country to country. While there is no tendency among the Europeans to emulate the Gadarene swine, there is a general acceptance of the inevitability of nuclear power and a keenness and enthusiasm to make a start now.

Frequent on-load rearranging of fuel may be an important factor in reducing power costs from second-round gas-cooled stations. Here is one group's approach to the problem

Fuel cycle optimization in power station design

by P. J. GRANT, M.A., Ph.D., F.Phys.S.

Head of Reactor Physics Section, General Electric Co. Ltd.

THE OVERRIDING REQUIREMENTS in nuclear power station design are safety and reliability. Subject to these two conditions the designer's aim is to produce electricity at the lowest cost and optimization of the fuel cycling scheme for the reactor can play an important part in reducing the total cost of power.

Study of fuel cycling schemes cannot usefully be carried out in isolation: it must be part of the overall station optimization which will take into account factors such as availability of capital, interest rate on capital, the size of the electricity system of which the station will be a part, the load factor etc. The detailed balance between these factors will influence the conclusion reached in any particular case but certain general features are normally common to all such studies. For a given core geometry the fuel cycle giving the lowest overall power cost is found; this is repeated for other cores until the best design, within the currently accepted assumptions and limitations, is found.

1. Continuous charge and discharge. Because of the high capital cost it is important in a nuclear power station reactor to avoid lengthy periods of 'outage' For an economic reactor design it is important that the maximum utilization of the fuel be obtained and if the limit on irradiation is caused by failure of the fuel element canning material rather than by reactivity considerations, as may well be the case, then occasional fuel element failure will be a normal feature of an economic design. To reconcile the requirements of negligible 'outage' and maximum fuel irradiation, it must be possible to charge and discharge fuel while the reactor is on load.

To minimize disturbance to the reactor during fuel charging it is also necessary to use the 'little and often' principle, replacing a few fuel elements or channels every day rather than carrying out a bulk charge and discharge scheme.

A continuous charge and discharge fuel cycle for the reactor is thus almost a necessity for a truly economic system. (This statement has been qualified because, although it is certainly true for most reactors, in a small one the additional cost of a more complicated charge-discharge machine might 'outweigh the saving obtained by using a continuous fuel cycle.)

2. Material limitations. For any type of fuel element the life will be limited by the effects of irradiation on its mechanical properties (although there may be a more stringent restriction on life due, for example, to reactivity changes). Irradiation may cause important changes in the fuel, the canning material, or both. For example, metallic uranium will slowly swell and distort under irradiation due to the accumulation of fission product gases in the metal; in time the swelling may be too large to be restrained by the can and this will fail. Uranium oxide is more resistant to irradiation damage than uranium metal but if a fuel element of uranium oxide were canned in beryllium then in time deterioration of the canning material would be expected due to the production of helium by fast neutron bombardment:

$$\text{e.g.} \quad Be^{9} + n \rightarrow He^{6} + He^{4}$$

Material limitations must be considered in detail when devising a fuel cycle and their effects minimized as far as possible.

3. Reactivity changes. As irradiation proceeds the fissionable isotope of uranium, U-235, is used up and from the capture of neutrons in U-238, plutonium is produced—Pu-239 and higher isotopes by successive neutron capture. The nuclear properties of plutonium are different from those of uranium and at any point in the reactor there results a variation of reactivity of the type shown in figure 1a. The exact form of the variation depends on the initial enrichment of the fuel, the relative proportions of fuel and moderating material, and the temperatures of the moderator and fuel. At different points in a reactor the reactivity variations will in general be out of step because of the variation of neutron flux, and hence rate of irradiation, from point to point in the core.

A well-conceived fuel cycle must obtain the maximum advantage from these reactivity variations and avoid undesirable effects such as large-scale distortion of the neutron flux which could be caused by the differences between the reactivity variations in different parts of the reactor core.

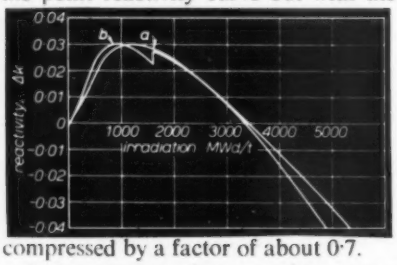
We can illustrate the interplay between the various

factors by examining the case of a typical UK gas-cooled reactor design. Fuel cycle optimization cannot be carried out by a simple series of steps in sequence; at most stages there are feed-back loops to earlier stages so that the calculations may have to be repeated several times.

The starting point for a fuel cycle study is the curve (e.g. figure 1a) of reactivity variation with irradiation at a point in the reactor—the point reactivity curve. In the preliminary stages this curve will be of the typical average behaviour in the core, but at a later stage it will require modification to take account of the temperature variations in the core and any fuel shuffling scheme since a change of environment of fuel means a change in the curve of reactivity variation. There are thus point reactivity curves appropriate to different positions in the reactor core.

Knowing the axial neutron flux distribution along a channel of fuel elements we can find the irradiation, and hence the reactivity change, at any point in the channel as a function of the mean channel irradiation. The individual changes are combined, using the appropriate averaging factors, to give the channel reactivity change as a function of its mean irradiation—the channel reactivity curve.

Since the central fuel elements in a channel are irradiated faster than those at the ends and since they are in a region of higher statistical importance, the channel reactivity curve is influenced largely by the behaviour of the fuel in the middle of the channel and, plotted as a function of mean channel irradiation, the reactivity curve of an unshuffled channel is similar in shape to the point reactivity curve but with the irradiation axis compressed by a factor of about 0·7.



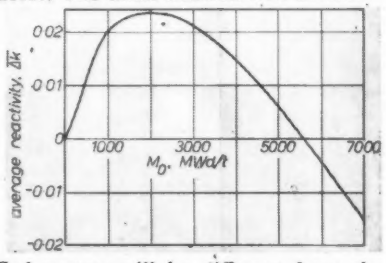
Typical curve for (a) point reactivity and (b) channel reactivity, showing the effect of axial inversion (Fig. 1)

It is apparent that an advantage can be gained if axial shuffling of fuel elements is possible since the less irradiated fuel at the channel ends can be brought to the central positions. For a given mean irradiation, provided that it is greater than a value roughly corresponding to the peak reactivity of the unshuffled channel, the reactivity of a shuffled channel is higher than that of an unshuffled channel so that:

a. With irradiation limited by reactivity the permissible irradiation is increased or the excess reactivity can be used profitably in other ways, or

b. With irradiation limited by fuel element failure there is a gain in irradiation since the *average* irradiation in the channel (instead of the irradiation of the most highly burned fuel element) can be equal, or nearly so, to the material limit. This gain is of the order of 30%

A typical channel reactivity curve, including the effect of 'axial inversion'—change of fuel element order e.g. 1,2, . . . 10 → 6,7,8,9,10,1,2,3,4,5—is shown in figure 1b. At this stage the channel curve will be only provisional because it depends on the irradiation at which inversion is carried out and the optimum value for this depends on the discharge irradiation which is not yet determined and may vary with radial position in the reactor. The axial neutron flux distribution for the shuffled system will be different from the assumed one and this may require a small correction to the reactivity curve.



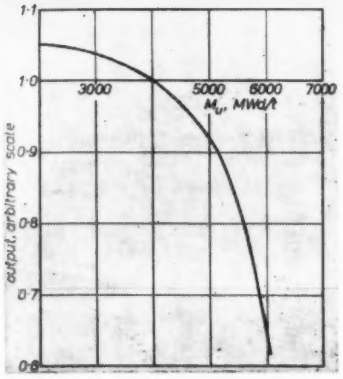
Average reactivity as a function of discharge irradiation (Fig. 2)

Core reactivity variation

For operational reasons a continuous fuel replacement scheme is required and this equilibrium condition of the reactor, during which a few fuel channels are changed each day and the overall reactivity variation is small, will be in force for more than 75% of the reactor life. It follows that the fuel cycle must be optimized with this condition in mind rather than the initial unirradiated state. The reactivity of any region of the core which constitutes a fuel cycling unit will be virtually constant and will be equal to the average irradiation of fuel channels distributed in irradiation from zero up to the discharge limit. If there are sufficient channels in the unit, the mean is equal to the net area in figure 1b, counting areas below the irradiation axis as negative, divided by the discharge irradiation, M_0. To determine the core characteristics as a function of discharge irradiation, a curve can be derived of reactivity *v.* M_0 for any region of the core or for the core as a whole. A typical curve is shown in figure 2.

In a power reactor the radial neutron flux distribution is flattened in order to increase the average power rating and decrease the capital cost per unit of the station. Flattening the flux increases the radial leakage of neutrons from the unflattened zone of the core. The degree of flux flattening possible in a given case therefore depends on the reactivity conditions in the unflattened zone of the reactor. The higher the reactivity the greater is the possible amount of flux flattening. From curves of reactivity *v.* M_0 it is possible to derive a curve of reactor heat output as a function of M_u, the discharge irradiation in the unflattened zone. A typical example is given in figure 3.

In the flattened zone of the reactor there is no radial leakage of neutrons and so the reactivity required to sustain the chain reaction is lower than in the unflat-



Reactor heat output as a function of M_u, the discharge irradiation in the unflattened zone (Fig. 3)

tened zone. One way of using this fact is to irradiate the fuel in the flattened zone to a higher value of M_0. Another way is to carry out *radial shuffling* of fuel channels.

Depending on the relative sizes of the flattened and unflattened zones and their mean neutron fluxes, it is possible in principle to cycle some or all of the fuel from the unflattened zone through the flattened zone. With a large flattened zone the feed of fuel from the unflattened zone will not be sufficient and new fuel will also have to be fed into the flattened zone. With a small flattened zone not all the fuel from the unflattened zone can be transferred to the flattened zone—some will be directly discharged. In a radial shuffling scheme the reactor output can be that appropriate to a low value of M_u while the mean discharge irradiation will be greater than M_u.

Such a fuel cycle, with radial transfer of whole fuel channels in addition to axial shuffling of fuel within a channel, requires extra operations from the charge machine and in any particular case this extra duty might necessitate a major change in the design of the charge machine. The extra cost of the more elaborate machine, and its possibly lower reliability would then need to be balanced against the saving in other costs obtained by radial fuel shuffling.

Typical curves for total power cost as a function of M_u for three possible fuel cycles are shown in figure 4 (a), (b) and (c). The figures have been arbitrarily normalized to unity at M_u = 4000 MWd/t on curve (a) and it has been assumed that the fuel cost is 25–30% of the total power cost.

It can be seen that radial shuffling could produce a reduction of about 3·5% in total fuel cost.

Material irradiation limit

So far it has been assumed that irradiation is limited by reactivity considerations alone. If there is a material limitation on irradiation the previous conclusions will be considerably modified. Figure 4 (d) and (e) show the effect of imposing a channel irradiation limit of 4000 MWd/t. Under these conditions the reduction in cost due to radial shuffling is reduced to about 2%. Taking into account the fact that a material irradiation limit implies a sensitivity to external conditions, temperature cycling, etc. and allowing also for the possibility of damage to fuel during handling, we may say that, in this instance, radial shuffling would not be economically desirable. In fact, even without a material limitation the advantage to be gained by radial shuffling is questionable. So far it has been assumed that the buy-back value of irradiated fuel is independent of irradiation. In fact, taking into account processing costs and the variation of plutonium and U-235 content with irradiation, the net value of irradiated fuel will vary in the way indicated in figure 5. However, the value is sufficiently constant not to affect markedly the curves of figure 4; the position of the point of minimum cost may change but the actual value of the minimum cost on any curve will be little altered.

Approach to equilibrium

The purpose of the fuel cycle during the approach to equilibrium is to convert the initial uniform zero irradiation of fuel in any zone of the reactor into the equilibrium spread of values from 0 to M_0 MWd/t. This must be carried out in the most economical manner possible but it must also allow for the possibility that the material limit on burnup may be lower than the value assumed.

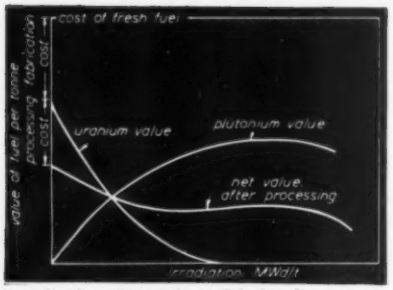
If the aim of the approach cycle were simply to reach the equilibrium condition as rapidly as possible, charge and discharge operations would start as soon as the reactor went on load; the rate of charge and discharge would be the same as that during the equilibrium cycle. By the time the discharge limit, M_0, had been reached, there would be a uniform spread from 0 to M_0 and the equilibrium condition would exist. From this point onwards all fuel discharged would have the irradiation M_0 but the mean irradiation of the first fuel load would be $M_0/2$.

Total unit cost of power as a function of M_u for various fuel cycles: (a) $M_F = M_u$. (b) $M_0 \neq M_u$ (M_F =7000 MWd/t) no material limit, (c) radial fuel shuffling, no material limit, (d) radial fuel shuffling, irradiation limit 4000 MWd/t, (e) no radial shuffling, irradiation limit 4000 MWd/t (Fig. 4)

It seems wasteful to start discharging fuel with zero irradiation and more sensible to delay the onset of cycling. Suppose that charge/discharge begins after an irradiation T, that the reactivity level must not fall below the value K_0 appropriate to the equilibrium cycle, and that the discharge limit for the first load of fuel is M_1, not necessarily the same as M_0.

During the first period, fuel will be discharged at a rate $M_0/(M_1 - T)$ times the equilibrium rate. (This rate cannot, of course, be allowed to exceed the capacity of the fuel-handling machine). When the first load of fuel has been discharged, there will be a spread of irradiation from 0 to $(M_1 - T)$ of the fuel in the reactor while the mean irradiation of the first load is 0·5 $(M_1 + T)$.

If the second load of fuel is now discharged at the equilibrium rate, at the end of the second period the equilibrium cycle will have been reached, i.e. spread of



Effect of burnup on net value of irradiated fuel (Fig. 5)

irradiation from 0 to M_0 in the reactor. The mean irradiation of the second charge of fuel will be 0·5 $(M_1 - T + M_0)$.

We can now examine the value to be given to M_1. First suppose $M_1 = M_0$. The mean irradiation of the first load is 0·5 $(M_0 + T)$, that of the second load 0·5 $(2M_0 - T)$, and the mean of the first two loads is $3M_0/4$. We see that, *in a straightforward fuel cycle, if $M_1 = M_0$ there is no economic gain by delaying the onset of cycling.*

If the limit on irradiation is material and not due to reactivity considerations, then in fact $M_1 = M_0$.

Intermittent charging scheme

One solution that has been proposed to this problem (Gallie *et al*, 1958) is to abandon the attempt to achieve a true equilibrium cycle and to adopt an intermittent charge-discharge scheme. Thus, in our example, at the end of the first period the fuel in the reactor is distributed in irradiation from 0 to $(M_0 - T)$. A period T is allowed to pass during which no fuel is discharged and at the end of this the fuel has irradiation ranging from T to M_0; fuel is now discharged at the same rate as the first load, i.e. $M_0/(M_0 - T)$ times the 'normal' equilibrium rate. The second load of fuel all receives an irradiation M_0 and at the end of this period the third load is distributed from 0 to $(M_0 - T)$. The cycle is then repeated indefinitely. By this means the gain in irradiation of the first load is preserved but at the expense of a higher discharge rate and a periodic fluctuation in reactivity.

Figure 6 shows the reactivity variation in any zone for the reactor already considered in figure 4 when $M_0 = 4000$, $T = 2000$ MWd/t. The discharge rate in the example would be twice that on the 'normal' cycle. It is seen that there is a large reactivity swing. Since the neutron flux is not constant across the reactor different zones will be out of step; nevertheless, to avoid large-scale flux distortions most of the reactivity swing in any region will have to be taken up by control rod movement. This means that the power output will be near that corresponding to the minimum reactivity level. Adopting a reasonably optimistic approach for this example the economic balance is :

Reduction in fuel cost over 25 yrs	5·6%
Reduction in power output	8·1%
i.e. increase in other power costs	4·2%

Since, roughly, the relative weighting factors of fuel and other costs are 1 : 3 we find:

Net increase in power cost	1·75%

In general there is nothing to be gained from the use of the intermittent scheme and it has to be accepted that, where there is a material limitation on burnup, the equivalent of one half-load of fuel has to be wasted in achieving the equilibrium spread of irradiation.

If there is no material limit on irradiation it can easily be shown that M_1 can be greater than M_0, as follows :

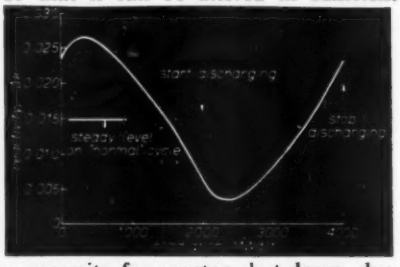
At the end of the first period the second charge of fuel is distributed in irradiation from 0 to $M_1 - T$. By definition, an irradiation spread 0 to M_0 gives the minimum reactivity allowed, *so at this time:*

$$M_1 - T \leqslant M_0$$

i.e. $$M_1 > M_0$$

The value $M_1 = M_0 + T$ is not usually possible because it is found that the reactivity falls below the allowed value at some earlier irradiation. However, M_1 can be substantially greater than M_0 and a useful saving in fuel can be obtained.

The remaining factor to be considered in a practical case is the capacity of the charge machine. If the proposed fuel cycle—especially the approach to equilibrium when the discharge rate may be increased—places too heavy a load on the charge machine, then the cost of an improved machine must be introduced as an additional variable. The capacity of the machine must also be considered in relation to the rate of failure of fuel elements when there is a material limitation on burnup. (This topic is covered in detail in the paper by Gallie *et al.*) So far it has been tacitly assumed that a material limitation is a sharp one; in fact there would be a progressive increase in the failure rate beyond a certain point. In the approach to equilibrium, where new type fuel elements with inexactly known failure point may be in use, the requirement is for flexibility in the fuel cycling scheme so that it can be altered in sufficient time to avoid any necessity for reactor shut-down, due to overloading of the charge machine, in the event of an earlier failure limit than expected. On the equilibrium cycle the mode of fuel element failure should be exactly known and a discharge limit can then be set which never leads to an unacceptably high incidence of fuel-element failure.



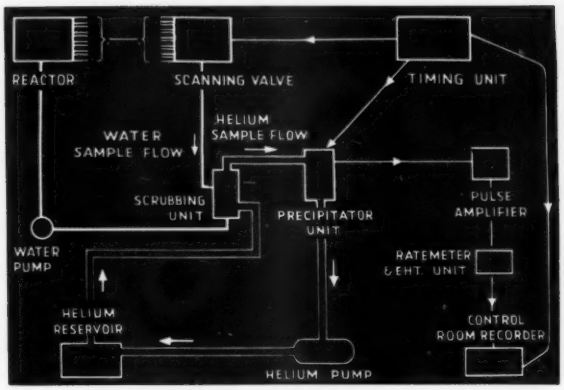
Reactivity fluctuation in any zone of the reactor considered in Figure 5 (Fig. 6)

It must be recognized that at the present time the study of possible fuel cycles is entirely a theoretical pursuit since there is no reactor in operation in which fuel can be charged and discharged under load. Nevertheless, this is a subject that bears so directly on the cost of nuclear power that it merits a considerable effort so that as many as possible of its implications are fully understood when the time comes for its application.

Reference :

Gallie, R. P., Gott, H. H., and Colmer, F. C. W., 'Problems of fuelling in industrial Calder Hall type reactors.' *1958 Geneva Conference*, Paper A/Conf/15/P37

After showing up well in recent tests, a new system developed from the Calder precipitation method, is to be installed in Dido and Pluto



Burst slug detection in water-cooled reactors

by DENIS ALIAGA-KELLY, B.Sc.
Senior Physicist, Plessey Nucleonics Ltd.

THE PRECISE MECHANISM which causes a fuel element to split and expose its fuel to the coolant is a subject of constant study in all countries. While the subject is really a metallurgical one, the importance of being able to estimate the life of a fuel element is vital from the economic point of view, and even more so is the ability to detect a failure before it has reached such a serious state that a major radiation hazard could occur.

There are several ways of detecting a break in the cladding of a fuel element—some of these are described below.

1. Pressure drop

The fuel element can may be pressurized and a pipe led from each to pressure gauges outside the reactor shell. A drop in pressure then indicates a break in the cladding.

The great number of pipes required to pass through the reactor shell, and the difficulty of loading and unloading elements fitted with such pipes, are objections to this method.

2. Tracers

Trace elements can be sealed into the fuel element can at manufacture, and detected should a break in the can allow some of the material to enter the coolant.

The number of possible tracers which could be used for such a system is very limited, and if the number of fuel elements is greater than the number of compatible tracers suitable for a particular reactor design, the system cannot be used for location of a break in a particular element. Some of the tracers proposed have a limited life in solution which also limits the method

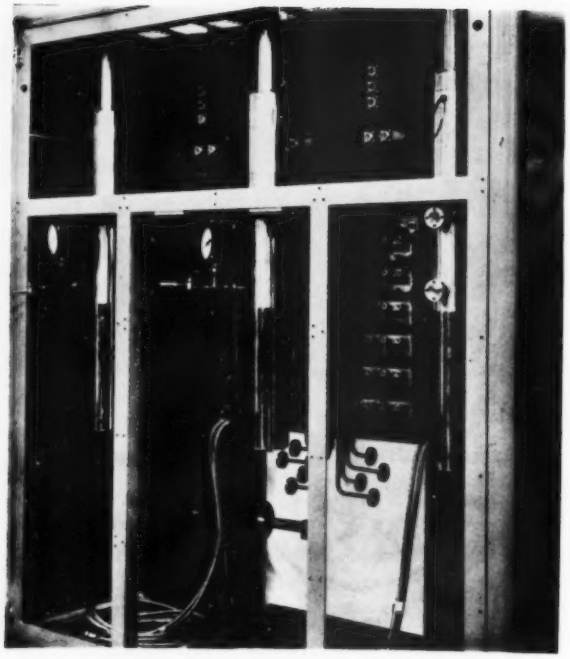
3. Direct monitoring

The coolant can be monitored directly for radioactivity, but the very high background due to neutron activation of the coolant itself while in the intense neutron flux in the core makes it difficult to detect the very small increase in total activity resulting from a crack in a fuel element. Energy discrimination can be used to observe only a narrow energy band in which would be expected only pulses due to fission products, but the complexity of the equipment needed makes this method unsuitable for long periods of reactor operation.

4. Delayed neutron detection

Some of the fission products have the property of emitting neutrons as they decay. The detection of these 'delayed neutrons' in the sample stream can form the basis for another method of detecting a fault using BF_3 proportional counters or neutron-sensitive scintillation counters. However, the reactor coolant, in this case water, also contains a quantity of O–17 which, in the neutron flux, is transformed into N-17. This in turn decays with a 4·14 second half-life by emission of a 1 MeV neutron, and this is comparable in energy with the neutrons emitted by the two fission products emitting delayed neutrons suitable for this detection system, Br-87 and I-137.

It is therefore necessary to delay the water sample transit between reactor and detector to allow the shorter lived, coolant-produced, neutrons to decay before attempting to count the slightly longer lived fission products. The half lives are: B-87, 55 seconds, I-137,



Equipment for Diorit, the 1 MW heavy water research reactor being built at Zurich by Reactor Ltd, comprises three rod precipitators, gas sample selectors and associated electronics (Fig. 1)

22 seconds. The yields of these two isotopes are also comparatively small—2% of Br-87 decays, and 6% of I-137 produces neutrons—so that the effect of the delay and small yields are limitations to this system.

5. Ion exchange column

Cation-type ion exchange columns have the property of removing most coolant and contamination activities from a water coolant stream while allowing only a limited number of fission products to pass through. A gamma scintillation spectrometer is allowed to monitor the effluent from the column, with its energy discriminator set to cut off all pulses due to activities below about 1 MeV and this provides the basis of another system

The water effluent from the cation column may also be passed through a second ion exchange column—of the anion type—and the gamma scintillation counter allowed to monitor the column itself. The column acts as a slow accumulator of fission products to give an integration effect. This method is suitable only for bulk monitoring of the coolant and is rather slow in response compared with other methods.

6. Precipitation

This method, which offers the quickest response and a very high sensitivity, depends on the fact that the fission product gases krypton and xenon, emitted from a faulty fuel element, decay into solids and then decay again, with beta emission in each case. A sample of water is taken to a unit called a stripper (or scrubber), the fission product gases are removed from the water by means of an inert gas, usually that used as the reactor blanket, and the combined gas sample is passed to a detector unit known as a precipitator. Here the gases pass through a chamber in which two electrodes are maintained at a high potential between them. If, during their passage through the chamber, krypton or xenon atoms decay into their daughters rubidium or caesium respectively, then the latter, being solids and highly charged positively, will be attracted to and deposit themselves on the negative electrode.

After a short period the negative electrode is moved into a well shielded enclosure where it is monitored with a beta detector. The presence of fission products is positively identified by the detection of secondary betas from the negative electrode when the rubidium and caesium atoms decay again to further daughters. The reactor coolant activities, whether gaseous or solids, do not exhibit this double decay process and hence this method gives a positive indication of fission products.

Rapid response to small breaks

The method offers several advantages over those described earlier, for example :

a. The response to a very small break in a fuel element is extremely rapid—a fault equivalent to the exposure of 0·1 mm² of natural uranium in the coolant is detected within less than 1 minute.

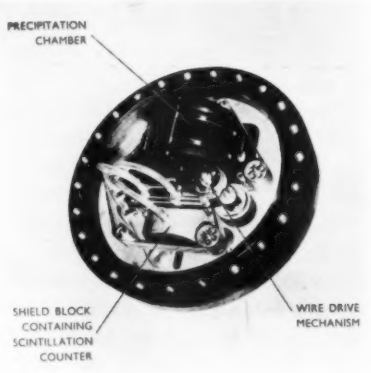
b. Large numbers of reactor fuel element channels may be scanned sequentially, so enabling a fault to be shown up as occurring in one particular channel.

c. The system is simple in principle, and has already proved most successful on the Calder Hall and other gas-cooled reactors. Decisions have also been made to use this method for the heavy water test reactors Dido and Pluto at Harwell.

d. It can be used with high temperatures and pressures.

e. As well as being used as a scanning system to monitor each fuel element channel in a reactor, it can monitor the coolant in bulk and also individual loop experiments inserted in the reactor. In the Dido system, for instance, all 25 fuel plate assemblies are monitored together. If a fault should occur, a scanner is brought into action which takes a sample from each assembly.

Figure 1 shows the detector units—the precipitators

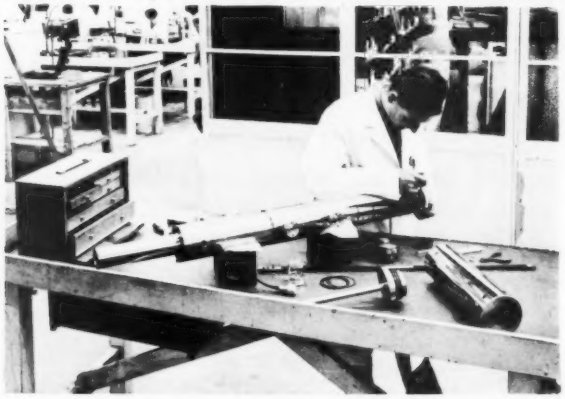


One form of precipitator unit in use at present, the Plessey Mk II, has a long endless wire, part of which acts as the negative electrode in the precipitation chamber and allows successive monitoring of different channels (Fig. 2)

—and associated gas sample selection equipment and electronics for Diorit, a 1 MW heavy water-moderated reactor being built by Reactor Ltd. near Zürich in Switzerland. In this case the stripping units, which extract the fission product gases from water samples from each fuel element channel, are mounted on the top of the reactor in shielded compartments, and only the inert stripping gas, with any fission product gases it has collected, is brought to the precipitators. Experimental work has shown that krypton and xenon can be extracted from water samples with efficiencies of about 80%, provided that the water surface containing the gases is well broken up.

Wire and rod precipitators in use

Two types of precipitator units are in use at present. The first uses a long endless wire, a portion of which acts as the negative electrode in the precipitation chamber. The latter is a cylindrical metal electrode which surrounds the wire (at earth potential) and is maintained at a high positive potential relative to it. The gas sample is allowed to flow through the precipitation chamber for a period, since it has been shown that this

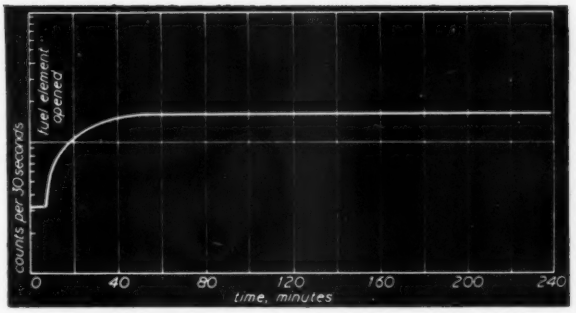


In another Plessey precipitator the wire is replaced by a reciprocating rod, with the advantage that the precipitation chamber can be small (Fig. 3)

increases the deposit on the wire, and then the portion of the wire which was in the precipitation chamber is moved mechanically into a sensitive beta scintillation counter which is shielded from external radiation. If the wire deposit contains fission products the counter detects them by the betas emitted.

The whole equipment is mounted in a gastight vessel and the size of this vessel and its strength is related to the pressure at which the unit is required to operate. The wire enables successive samples to be taken from different channels for monitoring in turn, and this allows the activity on each portion of the wire to decay by an appreciable amount before it is re-used. Figure 2 shows such a machine in one of its more recent forms (Plessey Mk. II precipitator)

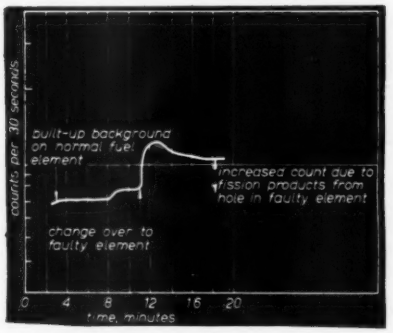
A different type of precipitator, in which the endless wire is replaced by a reciprocating rod, is shown in Figure 3 above. This rod moves so that the portion



Build-up of radioactivity background on a rod precipitator tested on Dido took about 40 minutes (Fig. 4)

in the precipitation chamber acts as the negative electrode on which the fission decay products are deposited, and is then moved into a cylindrical annular counter of the gas proportional type which detects the secondary betas. A device of this type has been tested successfully on Dido. It will be seen that, in this case, the size of the precipitation chamber is small—only about 400 cc. Use of a rod electrode instead of a wire enables lower polarizing potentials to be used while the electrostatic field configuration is improved. Also, the pressure vessel is comparatively small and shielding can be fitted external to the pressure vessel to reduce the counter background.

In this instrument, due to the fact that the rod is reciprocated, there will be a certain amount of build-up of long-lived fission product activity on the rod. It has been shown, however, from tests on Dido, that this reaches an equilibrium level in about 40 minutes and any defect in a fuel element then shows up as a step on top of the built-up background. The small chamber also assists in cutting down the level of this build-up since it reduces the probability that long-lived fission products will decay during the short time during which they are in the chamber. A graph is shown in Figure 4 of the build-up on a rod precipitator on Dido, on which



Sensitivity test showed that a specially inserted faulty element was positively detected (Fig. 5)

the steady level reached and maintained can clearly be seen. Figure 5 shows how, with Dido operating at the low power level of 500 kW, a faulty fuel element—one especially drilled with a 1/16 in. dia. hole through one plate of the element—is positively detected.

Acknowledgment :
The author wishes to thank Plessey Nucleonics Ltd. for permission to publish this paper, and the United Kingdom Atomic Energy Authority for permission to publish details of the tests on Dido, including Figures 7 and 8.

In designing a gas-cooled reactor heat exchanger, the straight optimization problem is between pumping losses and thermal efficiency

Evaluation of heat transfer surfaces for nuclear boilers

PART 1. Plain tubing

by B. G. EDISS, A.M.I.Mech.E., A.R.T.C.S., R. BILSBOROUGH, D.I.C. (Chem. Eng.) and F. CARR, B.Sc., A.R.C.S., D.I.C.

IN ANY GAS-COOLED REACTOR SYSTEM, particular attention must be paid to the power required to circulate the gas coolant as this power requirement may amount to as much as 10% of the output of the station. In British practice as it has been established to date, the principal pressure drop in the gas circuit occurs in the reactor. The pressure drops occurring in the boilers and in the ductwork are of approximately the same magnitude and each of these amount to perhaps 20% of the total coolant pressure drop.

In spite of the fact that the boiler pressure drop is a relatively minor part of the total, it is necessary in designing such boilers to recognize the importance of the power required to operate them. As has been pointed out in previous publications *(1, 2)*, the pumping power loss in the boilers does not constitute the whole of the power loss associated with them. Some account must also be taken of the irreversibility of heat transfer represented by the temperature difference between the gas and the water side. Numerical evaluation of this second power loss has been analysed in the above mentioned publications, and in this article the methods of evaluation used are as published in reference 2.

At first sight, plain tubes would appear to be the choice for transfer of heat from the reactor coolant to the working fluid, steam, since they are so much cheaper per foot than any form of extended surface, and since the boiler would be considerably cheapened by ease of manipulation and handling.

Consideration of the merits and demerits of plain tubes will guide in the determination of the relative advantages of the two methods of deployment—'staggered' formation and 'in line' formation. Colburn *(3)* recommends that the following equation be employed for the gas side heat transfer coefficient for plain tubes arranged in staggered formation:

$$\frac{h_m D_o}{k_f} = 0{\cdot}33 \quad Pr^{0{\cdot}3} \quad Re^{0{\cdot}6}$$

where h_m = mean gas side film coefficient
D_o = tube outside diameter
k_f = thermal conductivity of gas film
Pr = Prandtl number
Re = Reynolds number, based on the minimum flow area.

and for tubes in in line formation he suggests that the constant 0·33 be reduced to 0·26. In staggered formation h_m has a value 27% greater than in line formation.

For plain tubes in a matrix, the reactor coolant pressure drop for turbulent flow normal to the matrix face area, N rows deep, is given by:

$$\triangle P = \frac{4fN(V_{max})^2\rho}{2g144} \text{ lb/in.}^2$$

where V is the velocity of gas between two tubes.

For tubes in staggered formation

$$f = \left[0{\cdot}23 + \frac{0{\cdot}11}{(X_t - 1)^{1{\cdot}08}} \right] \left[\frac{D_o G_{max}}{\mu_f} \right]^{-0{\cdot}15}$$

and for 'in line' formation

$$f = \left[0{\cdot}44 + \frac{0{\cdot}08\, X_L}{(X_t - 1)^n} \right] \left[\frac{D_o G_{max}}{\mu_f} \right]^{-0{\cdot}15}$$

in which μ_f = viscosity of gas film
X_t = ratio of transverse pitch, to tube diameter

$$n = 0{\cdot}43 + \frac{1{\cdot}13}{X_L}$$

where X_L = ratio of longitudinal pitch to tube diameter (*Jakob, ref 4*).

For tubes in staggered formation it follows, therefore, that for any given transverse pitch, for values of the vertical pitch greater that that which gives the velocity in the diagonal pitch equal to that in the transverse pitch, the pressure drop remains constant since V_{max} and G_{max} are calculated from the transverse pitch. When the vertical pitch is less than that which gives the velocity in the diagonal pitch equal to that in the transverse pitch, the pressure drop increases, because V_{max} and G_{max} are computed now from the diagonal pitch. Therefore if the vertical pitch is such that the velocity of gas in the diagonal pitch is equal to that in the transverse pitch the pressure drop is at its minimum and the matrix height is not penalized.

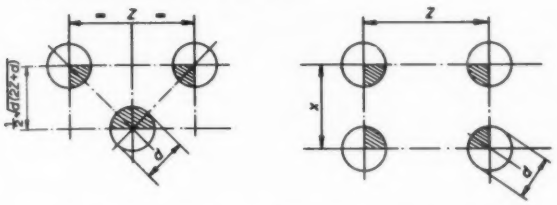
For tubes in line formation there is no clearly de-

fined minimum point for pressure drop—the greater the longitudinal pitch the greater the pressure drop.

From Figure 1:

Matrix volume $= \frac{1}{2} Z[d(2Z + d)]^{\frac{1}{2}}L$

Heat transfer surface $= \pi dL$



Tubes in 'staggered' and 'in line' formation (Figs. 1 & 2)

Therefore, heat transfer surface per unit volume $= T_S$

$$= \frac{2\pi d}{Z[d(2Z + d)]^{\frac{1}{2}}}$$

From Figure 2:

Matrix volume $= ZxL$

Heat transfer surface $= \pi dL$

therefore, heat transfer surface per unit volume =

$$T_L = \frac{\pi dL}{ZxL} = \frac{\pi d}{xZ}$$

For matrices of unit volume, which perform identically, other than in pressure drop,

$$U_L A_L = U_S A_S$$

where U = overall heat transfer coefficient, A = heat transfer surface, the suffix L refers to 'in line' formation and suffix S refers to 'staggered' formation

Therefore $$\frac{U_S}{U_L} = \frac{A_L}{A_S} = \frac{T_L}{T_S}$$

Since $$U = \frac{h_o h_{io}}{h_o + h_{io}}$$

where h_o = outside film heat transfer coefficient, and h_{io} = inside film heat transfer coefficient referred to the outside surface.

therefore $$\frac{U_S}{U_L} = \frac{h_{oS}}{h_{oS} + h_{io}} \quad \frac{h_{oL} + h_{io}}{h_{oL}}$$

since h_{io} is equal in both cases.

From Colburn's equation:

$$\frac{h_{oS}}{h_{oL}} = \frac{0{\cdot}33}{0{\cdot}26} = 1{\cdot}27$$

therefore $$\frac{T_L}{T_S} = 1{\cdot}27 \quad \frac{h_{oL} + h_{io}}{1{\cdot}27\, h_{oL} + h_{io}}$$

But $$\frac{T_L}{T_S} = \frac{\frac{\pi d}{xZ}}{\frac{2\pi d}{Z[d(2Z + d)]^{\frac{1}{2}}}} = \frac{[d(2Z + d)]^{\frac{1}{2}}}{2x}$$

Since $X = Z/d$ and $X_L = X/d$

$$\frac{T_L}{T_S} = \frac{(2X_t + 1)^{\frac{1}{2}}}{2X_L}$$

therefore $$\frac{(2X_t + 1)^{\frac{1}{2}}}{2X_L} = 1{\cdot}27 \quad \frac{h_{oL} + h_{io}}{1{\cdot}27\, h_{oL} + h_{io}}$$

therefore $$X_L = \frac{(2X_t + 1)^{\frac{1}{2}}\,(1{\cdot}27\, h_{oL} + h_{io})}{2{\cdot}54\ (h_{oL} + h_{io})}$$

$$X_L = \frac{(2X_t + 1)^{\frac{1}{2}}\ (1{\cdot}27\, h_{oL}/h_{oi} + 1)}{2{\cdot}54\ [h_{oL}/h_{oi} + 1]}$$

Longitudinal pitch in 'in line' formation producing a matrix to do similar duty as one of 'staggered' formation with the same transverse pitch (Fig. 3)

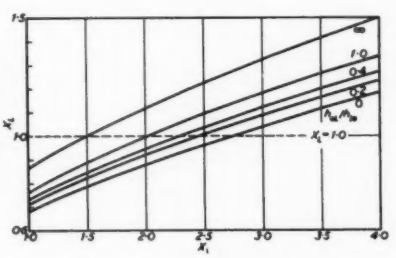
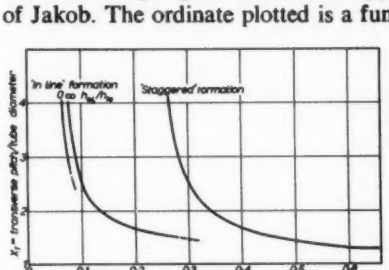


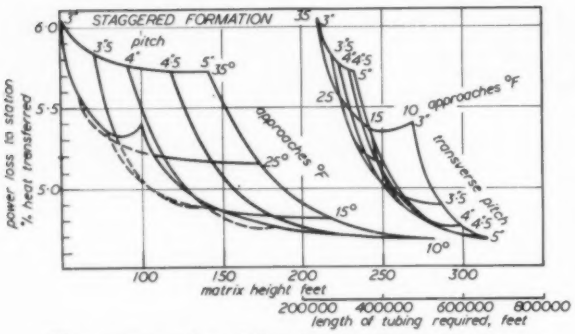
Figure 3 is a plot of the above expression. This is simply a plot of longitudinal pitch in in line formation which will produce a matrix to do a similar duty, per unit volume, as a matrix of staggered formation having the same transverse pitch. The staggered formation has a longitudinal pitch fixed by the criterion mentioned earlier—that the velocities in both the transverse and diagonal pitches must be equal.

Figure 4 shows the pressure drop over the matrices obtained using Figure 3, from the appropriate equation of Jakob. The ordinate plotted is a function of the pressure drop since to know the actual pressure drop the actual case must be known. As can be seen, the pressure drop for in line formation is considerably less than that for staggered formation.

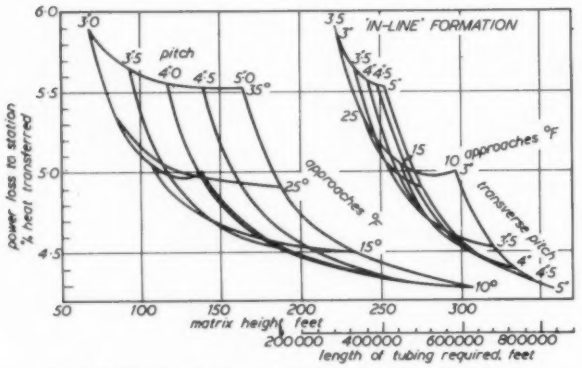


Pressure drop over the matrices obtained using Figure 3 (Fig. 4)

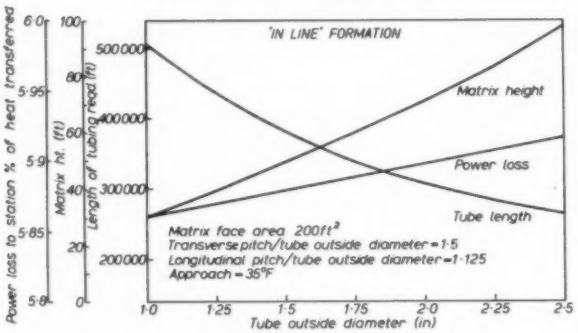
Since gas side pressure drop is so costly in nuclear boilers, it must not be inferred that, for values of X_L less than 1, staggered formation is to be preferred. It could be that, even though both tube length and matrix volume are lower for staggered formation at this condition the benefits accrued from a much lower pressure drop with in line formation may be so considerable as to outweigh these advantages, even though the optimum pitches cannot be used for in line formation. In the



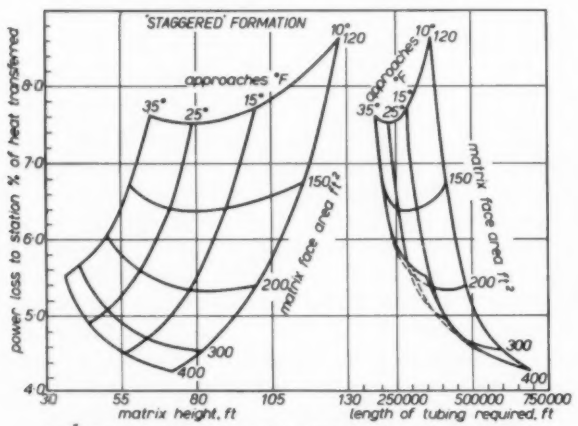
Effect on power loss of changing transverse pitch and approach temperature in 'staggered' formation (Figs. 5 & 6)



Effect of changing transverse pitch and approach temperature in 'in line' formation (Figs. 7 & 8)



Effect of change of tube diameter (Fig. 9)


'STAGGERED' FORMATION
power loss to station % of heat transferred
approaches °F
matrix face area ft²
matrix height, ft
length of tubing required, ft

Variation of power loss with matrix height and tube lengths (Figs. 10 & 11)

manipulation of these curves it should be remembered that comparisons can only be carried out for tubes of the same size, and that for in line formation X_L can never be less than unity.

In order to make a full comparison between in line and staggered formations, calculations have been carried out for various transverse pitches, approaches, and face areas. The calculations have been carried out for a typical nuclear boiler with economizer, evaporator, and superheater sections for a dual pressure cycle.

Figures 5 and 6 show the effect of changing the transverse pitch and approach temperature for a constant tube size and matrix face area for staggered formation. It is clearly seen that for any constant value of approach temperature, the matrix height and length of tubing required decrease with reduction of the transverse pitch; and that for any constant value of transverse pitch, the matrix height and length of tubing required increase with reduction of approach temperature.

For in line formation Figures 7 and 8 are of essentially the same form as the corresponding ones for staggered formation mentioned above. The differences between the two sets of curves are that in line formation requires more tubing and a higher matrix, but the power loss is lower for equivalent conditions.

All the foregoing is for one particular size of tube. In order to observe the effect of change of tube diameter Figure 9 was produced. This curve shows that as the tube outside diameter decreases, for constant values of the ratios X_t and X_L, and for a constant value of matrix face area and approach temperature, the power loss decreases but the amount of tubing increases. The tube thickness conforms to *ASME Boiler and Pressure Vessel Code 1952*, Section VIII-Unfired Pressure Vessels. This curve is for in line formation only; a similar curve could be produced for staggered formation, the conclusions from each curve being identical.

From Figures 5 to 7 it is apparent that in line formation requires over 20% more tubing, depending upon the condition employed, and for the range of values of transverse pitch the matrix height is always greater than that given from staggered pitch.

A comprehensive study of power loss is possible only when the tube proportions and pitches are fixed. Figures 10 and 11 show the variation of power loss for various matrix face areas and approach temperatures with the matrix height and length of tubing for staggered formation. Similar curves may be produced for in line formation; the power loss will be slightly lower and the matrix height and tube length required noticeably higher.

References

1 Carr, F. 'Dradwell boilers', NUCLEAR POWER, 1957 (October) p.416-9
2 Carr, F., Rounthwaite, C. and Young, P.A. 'Evaluation of finned tubes for steam generated in gas-cooled power reactor system', 1958 Geneva Conference, paper A/conf. 15/P/2327
3 Colburn, A.P., Trans. Inst. Chem. Engrs. 1933, 29, p.174
4 Jakob M., Trans. A.S.M.E. 1938, 60, p.384

(to be continued)

Cross Section by GRACCHUS

ON a Tuesday in June the AEA snipped a few strands of wire and let a party of pressmen into the sacred acres of Aldermaston. They weren't really in of course. Not into the bomb department that is. The idea - a good one - was to show something of the important fundamental research that is going on at the Weapons Establishment. As it happened, the newspapers dismissed this in a few lines and built their main stories round the press conference which Sir William Penney gave afterwards.

He was in great form, putting everyone at ease by remarking that scientific work could not flourish long behind high fences. Questioned about possibilities of 'peaceful' nuclear explosions, Penney said in his soft Kent burr that he 'wasn't sure.' But they were studying it. It wasn't exactly a project. Just a study. They wanted to know if the sort of hole they could produce would be of any use to anyone.

Introducing the tandem Van de Graaff machine, Dr Allen recalled an interesting piece of history. When he opened Metrovick's high voltage laboratory in 1930 Rutherford spoke of his requirements for an idea particle accelerator. 'What we require,' he said, 'is an apparatus to generate a potential of the order of 10 million volts, which can safely be accommodated in a reasonably sized room, and operated by a few kilowatts of power. We require, too, an exhausted tube capable of withstanding this voltage. I see no reason why such a requirement cannot be made practicable by the use of oil or of air under pressure, but these are problems for the future.' I don't think Rutherford would consider the AWRE's skyscraper building which houses the tandem as a 'reasonably sized room' but otherwise his requirements have been met in full 29 years after - and by the firm he gave them to.

●

AN unexpected but nonetheless welcome champion for the metric system emerged in the controversial figure of Lewis Strauss, ex-Secretary of Commerce and previously AEC chairman. Speaking before the American Physical Society in Washington on May 1, Admiral Strauss said 'I have long been convinced that ultimately the United States must shift to the Metric system.' He then went on to produce a cogent argument for this view and in particular he maintained that the space flight people had a wonderful opportunity of using it from the start.

In nuclear energy the situation is quite ludicrous, with both metric and British systems living alongside. I have before in this column referred to the incredible fact that while temperatures of the gas in a gas-cooled reactor are generally referred to in terms of Celsius degrees, when the heat is transferred to the steam it reappears in Fahrenheit degrees. The greatest culprits in this business are of course the Americans themselves. For some reason I have never been able to fathom they seem to like our units better than we do ourselves and if Mr. Strauss can indeed persuade American engineers to make a change, then I'm sure we would not be long in following suit.

The complete changeover would of course take many years - Mr. Strauss referred, for example, to the system of land survey. But surely for a start it should be possible to throw overboard almost immediately the absurd Fahrenheit system. Nuclear energy is still young enough to cope with this and similar changes. Admiral Strauss's conviction, by the way, did not end with a mere speech : he requested the Director of the National Bureau of Standards to set up an advanced planning group to assemble all available documentation and to identify possible courses of action.

He also referred to the collaboration in this field between the American and British Associations for the Advancement of Science. Last year the BA set up a metric committee under Sir Hugh Beaver to go into the whole business - including decimal coinage. Its report, expected round the turn of the year will be awaited with interest. One cannot however forget that successive Royal Commissions over the last 50 years have advocated a change but in every case Parliament refused to do a thing about it.

●

IT was a heavenly day. The Naval detachment presented arms, the Royal Marines band crashed into the National Anthem, Prince Philip's hand rose to the salute. The whole world stood still. At that precise moment a little girl in a white frock walked slowly across the parade ground, oblivious of the solemnity of the occasion. We were assembled of course to see H.R.H. lay the keel of the Skipnought - sorry, Dreadjack - our first nuclear powered submarine.

There she was, simply a prefabricated ring, rather sharply tapered so that we couldn't really get much idea of the maximum diameter. No keel of course - just like an airplane fuselage really. Behind was a partially completed submarine of the Porpoise class, looking for all the world like a nuclear sub.

All the way through the ceremony there was a small yacht anchored off the end of the slipway. As soon as the Prince left the dais she hoisted sail and left. It was a bright red sail. 'Russians, I expect,' someone said.

International Transistor Convention

APPLICATIONS of semiconductors in nuclear energy work were discussed in several papers presented at the International Convention on Transistors held by the Institution of Electrical Engineers in London from May 21–27. In addition to their growing use as a replacement for thermionic valves in instrumentation, reference was made to the interesting possibility of using semiconductors as radiation detectors.

C. A. Klein and W. D. Straub (Raytheon Mfg. Co.) for example, said that quantitative observations of pile-neutron effects in germanium and silicon suggested their use as fast-neutron dosimeters, especially in mixed neutron-gamma fields. In order to determine neutron-response characteristics of semiconductor materials for general dosimetry applications, more information is needed on the extent to which the damage is actually energy dependent. In the present state of the art, the development of semiconductor dosimeters for fast neutrons of known energy spectrum should be rewarding. On the other hand, it is well known that thermal-neutron captures by lattice nuclei have only a small effect on the electrical properties of germanium or silicon crystals. But slow-neutron reactions yielding fast charged particles or ions may result in enhanced, highly localized damage of practical interest for thermal-neutron dosimetry. A suitable arrangement combining a high-resistivity *p*-type germanium foil with thin linings of lithium-6 appears to be a convenient tool for the estimation of biologically significant thermal-neutron doses. Analytical and experimental work done on semiconductor dosimeters designed on these lines was presented.

Promising for particle studies

Reporting work at Atomic Energy of Canada on gold-germanium junctions as particle spectrometers J. M. McKenzie and D. A. Bromley pointed out that a charged particle in passing through a semiconductor loses energy by forming electron hole pairs; an average of about 3 eV is required to form each pair. If the particle ionizes near a reverse biased junction the minority carriers cross the junction to give a current pulse. The occurrence of this pulse can be used as a means of detecting the particle, while a measurement of the size of the pulse or its time integral determines the particle energy.

The junctions are formed by sputtering a very thin layer of gold on a prepared germanium surface. The charged particles enter the junction through the gold layer.

To obtain a spectrum of particle energies expended in the junction, the current pulse from a reverse biased junction is integrated by the RC network formed by the junction self capacitance in series with a high resistance. The resultant pulses, after suitable amplification and differentiation, are analysed with a kicksorter.

The results obtained by using protons, deuterons, He-3 and He-4 ions show that the output pulse is proportional to the incident particle energy—provided the particle range does not exceed the effective junction thickness. Also, the pulse height is not dependent on the type of particle provided the junction bias is maintained above a minimum value ($\sim$ 1 volt) required to prevent recombination.

A typical junction, 2×2 mm surface area, operated at liquid nitrogen temperature gives an energy resolution (width at half maximum) of about 3% for 5 MeV alpha particles. The noise makes no significant contribution to the resolution width. The pulse height is proportional to particle energy for protons $< 3{\cdot}5$ MeV, for deuterons $< 4{\cdot}5$ MeV, for alpha particles < 11 MeV and for O-16 ions < 60 MeV. This makes the device particularly useful for studying alpha particles in the presence of high fluxes of charged particles with lower specific ionization, or neutrons or gamma rays. As an example, the Li-7 + He-3 reaction was mentioned. This reaction gives alpha particle groups as well as protons, deuterons, neutrons, and gamma rays. The pulse rise time is less than 3×10^{-9} secs. This fast rise time is particularly useful in particle-particle and particle-gamma coincidence studies.

Fast pulse generation

Avalanche transistors were dealt with in papers by J. L. Moll of Stanford University and G. B. B. Chaplin and others from Harwell. Moll said one of the newest applications of transistors was the use of the avalanche mode to generate millimicrosecond pulses—a method first used by Chaplin. For this, Moll said the avalanche transistor is used as a monostable multivibrator. The requirement of the thin base prescribes the speed with which the transistor switches when it is triggered from its monostable state. Another important transistor requirement relates to establishing the monostable state. In particular, if the base resistance is very high, base current tends to forward bias the emitter junction and cause self-oscillations. As the undepleted base becomes very thin it becomes impossible to find a bias point at which the transistor is simultaneously capable of producing fast pulses and is stable.

When the circuit is at the stable point, the transistor collector is avalanching with a multiplication in the range of 3 to 10. The transistor emitter has a slight reverse bias. The collector-base voltage is slightly greater than the collector-emitter voltage. A fast pulse on the base or emitter in the direction to forward bias the emitter has the immediate effect of lessening the voltage on the collector-base diode thereby decreasing the initial multiplication. If the transistor triggers before the collector-base voltage has built up to its initial value the pulse will be made slower. That is, short trigger delay and narrow pulses are somewhat contradictory requirements and must be balanced against each other.

The requirement of stability at the initial operating point as well as ease of triggering places a lower limit on allowed base thickness. For body

breakdown at 50 volts for *n-p-n* germanium transistors, the undepleted base thickness when breakdown voltage is applied to the collector should the greater than about 1 micron.

The requirement of speed, and of a monostable operating point with multiplication of 3 to 10 allows only a very slight tolerance on the base layer thickness of an alloy type transistor. The requirements for fast avalanche transistors can be met easier by a thin graded base as is obtained in the diffused base-alloyed emitter structure. However, in the commercially available structures of this nature the series collector resistance limits the speed to pulse widths of several millimicroseconds.

Chaplin in a paper with A. R. Owens, on designing avalanche transistor trigger circuits, said that with present transistors there is a large spread of avalanche voltage between individual specimens, and described a method of designing trigger circuits which require no adjustment when transistors are changed.

Some selection of transistors is necessary for fast operation, and it was found that of the transistors tested, which had α cut-off frequencies in the region of 10 Mc/s, about 20% had avalanche rise times less than 10 millimicrosec, 10% less than 3 millimicrosec, and 5% less than 1·5 millimicrosec. Circuits were described for generating pulses with rise time of 1 millimicrosec and having any width from 1 millimicrosec to several microseconds at half height.

The collector current of an avalanching transistor may build up to 0·5 amp in a few millimicroseconds and no suitable diodes have been found for shaping such waveforms. However, good results have been obtained by using the non-linear capacitance of diodes biased in the reverse direction.

In a paper on *Transistor stages for wide-band amplifiers* Chaplin together with C. J. N. Candy and A. J. Cole, described several practical circuits and showed how they could be made to accept wide variations in transistor characteristics. A third paper by Chaplin, this time with A. R. Owens and A. J. Cole, described a sensitive transistor oscillograph with d.c. to 300 Mc/s response. This corresponds to a rise time of about 1·5 millimicroseconds and a sensitivity which gives a full-scale deflexion for an input of a few hundred millivolts. The instrument has been used at Harwell for about six months on design of high-speed computing circuits, nuclear coincidence circuits and pulse generators, and the investigation of thin magnetic films. It has also been used to evaluate the response of a variety of semiconductor devices to millimicrosecond pulses.

About 150 papers were presented to the Convention. The complete record will be published by the IEE in Vol 106, Part B of their *Proceedings*.

Nuclear Technology | Radiation

Making some uncommon isotopes

METHODS of preparation of certain uncommon isotopes are described in a recent UKAEA report CAERE I/M 53) by C. E. Mellish and J. A. Payne. The methods used for their separation are not original, except in detail, but have usually been evolved as the quickest and most convenient of the methods available for occasional use. Four of the nuclides are made in the Harwell cyclotron, ^{7}Be, ^{52}Mn, ^{148}Pm, and ^{48}V, one in the Birmingham cyclotron, ^{85}Sr, and the other three ^{199}Au ^{111}Ag, and ^{233}Pa, by the (n, γ) reaction followed by β-decay in nuclear reactors at Harwell.

Beryllium-7

This is formed by irradiation of carbon in the cyclotron with 160 MeV protons—^{12}C (p,3p3n) ^{7}Be. The highest quality graphite available is used for the target in the shape of a block 1½ in. high presenting a thickness to the incident beam of about 1½ in. In such a target about 500 microcuries of ^{7}Be are formed in one hour of operation at the maximum beam current.

After decay of the large amount of ^{11}C formed ($T\frac{1}{2} = 20$ minutes), the activity in the target consists of radiochemically pure ^{7}Be, and the chemical separation necessary is the removal of graphite and the small amounts of impurities in the graphite.

Manganese-52

About one millicurie of ^{52}Mn ($T\frac{1}{2} = 6$ days) is formed in one hour in the Harwell cyclotron, by bombardment of an iron target with 160 MeV protons. Also present in quantity are radioactive isotopes of scandium, vanadium, chromium, iron, and cobalt, and the manganese is separated by distillation of Mn_2O_7 from a mixture of sulphuric and nitric acids and potassium periodate, after the iron target has been dissolved in aqua regia and excess chloride removed by boiling with sulphuric acid.

Promethium-148 ($T\frac{1}{2}$ 5·3 and 42 days)

This has been made by the bombardment of separated $^{148}Nd_2O_3$ with 12 MeV protons in the Harwell cyclotron. 12 mg of the neodymium oxide were wrapped in aluminium foil, being held in position with Durofix, and irradiated for 5 hours.

The aluminium foil was dissolved, after irradiation, in dilute caustic soda solution, and the Nd_2O_3 and Durofix centrifuged off. This mixture was dissolved in conc. H_2So_4/HNO_3 and the neodymium and promethium precipitated with ammonia as the hydroxide. The hydroxides were dissolved in dilute acid, and separated by ion exchange methods. The total yield of ^{148}Pm was about 20 microcuries.

Vanadium-48 ($T\frac{1}{2}$ 16 days)

Irradiation of titanium metal in the Harwell cyclotron with 20 MeV protons gives a yield of about 1 millicurie of ^{48}V per hour. The target is dissolved in HF, and then evaporated to dryness with sulphuric acid. The residue is fused with sodium carbonate and sodium nitrate, and the vanadium leached from the cooled mass with water.

Strontium-85 ($T\frac{1}{2}$ 65 days)

Rubidium chloride is irradiated in the Birmingham cyclotron using the reaction ^{85}Rb (d, 2n) ^{85}Sr. The yield from one hour's irradiation is of the order of 1 millicurie.

The rubidium chloride (about 1 g) is dissolved in water, and 50 mg of barium chloride added. Addition of ammonium carbonate precipitates $BaCO_3$, and the strontium-85 is carried down on the precipitate. This precipitation of strontium separates it from nearly all the rubidium, and also copper and ^{65}Zn from the target backing. Dissolution in HCl and ion exchange follows.

Gold-199, and Gold-195, 196

Gold-199 is made by irradiating platinum in a reactor, when ^{199}Pt is formed which decays with a 30-minute half life to ^{199}Au. ($T\frac{1}{2}$ 3·15 days). Irradia-

tion of platinum in the Birmingham cyclotron gives neutron-deficient gold isotopes such as ^{193}Au, and ^{196}Au. The separation of all these gold isotopes is performed as follows.

The platinum target is dissolved in aqua regia and the solution evaporated to dryness. The residue is taken up in 30 ml of conc. HNO_3, which is evaporated to 10 ml. This solution is then diluted with 120 ml of water, and the gold extracted with two portions of ethyl acetate. The gold is finally supplied as a solution in HCl.

Silver-111 ($T_{\frac{1}{2}}$ 7·5 days)

Palladium, when irradiated in the pile, gives the radioactive isotope ^{111}Pd which decays to ^{111}Ag with a half life of 22 minutes.

Palladium metal is dissolved under reflux in concentrated nitric acid, and the resulting solution diluted five times. To this solution, in the cold, is added about 100 mg of mercurous nitrate, followed by dilute HCl until all the mercury is precipitated. The precipitate, which carries the silver, is centrifuged off, dissolved in concentrated nitric acid, and boiled to convert all mercury to the mercuric state. The mercury is then extracted into ethyl acetate after diluting the solution 10–20 times with water; the silver remains in the aqueous layer as a carrier-free solution in dilute nitric acid.

Protactinium-233 ($T_{\frac{1}{2}}$ 27 days)

Irradiation of thorium in the pile gives ^{233}Th, which decays with a 23-minute half-life to ^{233}Pa. ($T_{\frac{1}{2}}$ 27 days).

The full memorandum gives complete literature references.

Nuclear Technology Materials

Zircaloy - a new corrosion problem

SEVERE localized corrosion of zircaloy-2 in steam under pile irradiation has been observed and reproduced by workers at Harwell. Reporting in UKAEA report C/R 2826, K. Alcock and B. Cox say that the fact that complete penetration of specimens 0·04 in. thick occurred in less than 14 days under irradiation in steam at 300°C has obvious implications for reactors in which these conditions are likely to exist. So far it has not been possible to offer a satisfactory explanation of this localized oxidation and further work is in progress to attempt to define the conditions under which such attack does and does not occur.

At the AERE an investigation of the corrosion resistance of zirconium alloys has been carried out for some time with a view to their use in a homogeneous reactor experiment. As a control to provide comparison with tests in uranyl sulphate a series of tests were carried out with the specimens in demineralized water. These were normally carried out in a titanium autoclave and it was due to the failure of this apparatus on one particular test run that the corrosion was noticed.

The autoclave was about 1¼ in. dia. 8¼ in. long and had an internal volume of 18 ml. Two of these experiments were installed simultaneously in a vertical 4 in. hole in the Bepo pile.

The zircaloy samples were machined from ½ in. extruded rod and were in the form of washers 0·04 in. thick with a 9/64 in. hole. The specimens were polished metallographically, washed and degreased. Up to eight washers were mounted on the central ⅛ in. dia. thermocouple well of the autoclave. They were separated from each other by titanium spacers and held in compression by a titanium nut at the bottom and a light titanium wire spring at the top.

After pressure testing with oxygen and filling with demineralized water the autoclave with the specimens was loaded into the pile. It was intended to run the experiment at 300°C for 10 weeks at the normal pile power of 5·6 MW (including weekend shutdowns) but after only 14 days of normal operation the autoclave failed and the experiment was unloaded during the next scheduled shut-down. The specimens were not examined immediately since it was thought that no useful information would be forthcoming. But when they were, it was apparent that all specimens had suffered localized attack to a greater or less degree.

In all cases except one the attack appeared to have originated at either the inner or outer edge of the washers: the exception was near an identification stamp. The corrosion was observed as a swelling of the metal locally with extensive cracking penetrating right through the specimen, the cracks being filled with white oxide. Specimens were examined by both optical and electron microscope. Calculations showed that the samples were probably exposed to the steam phase for about 3 or 4 days at the most.

After irradiation for 3-4 days in steam at 300°C, this specimen shows two areas of localized oxidation connected by ridges of white oxide

To investigate the reproducibility of the effect an experiment was carried out in which specimens were deliberately exposed to steam. This ran for a fortnight in Bepo at 300°C using both new specimens and also two from the previous experiment. Broadly speaking, the results of the two experiments were comparable. A specimen from the first experiment was also exposed to 300°C steam for 7 days with no irradiation. This indicated that the severe attack does not take place in these circumstances.

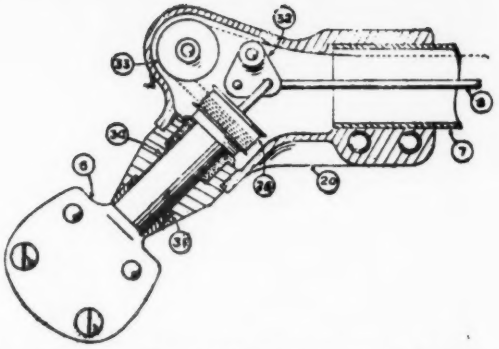
Seven possible causes

The report discusses possible explanations of this phenomenon under the following heads; some peculiarity in the original zircaloy 2 billet; chemical or metallurgical effects due to the method of specimen preparation; chemical factors due to some peculiarity in the experiment; possibility of a Chalk River type of hydriding attack occurring at lower temperature; stress corrosion similar to the stainless steel type of attack; electrochemical effects resulting from contact with titanium at the points of nucleation; a direct effect of irradiation in steam (e.g. due to reactive chemical species formed).

Further work is in progress to investigate these possibilities systematically.

Simple economic manipulators

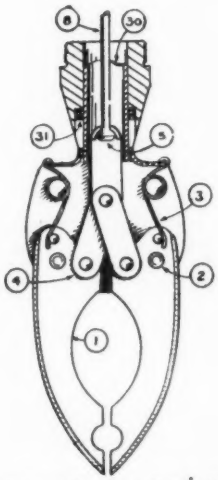
Carter & Viner's range now includes over-the-wall models



Claw head rotating mechanism. **6.** Swivel head; **7.** Main tube; **8.** Pull rod; **20.** Head castings; **26.** Cable drum; **30.** Bearing housing; **31.** Ball bearing assembly; **32.** Pull rod rocker and **33.** Cable pulley

Some ten years ago the principal of a general engineering works got tired of going up and down ladders to get spare parts and other stores off shelves. He told his engineer to make him a tool with which he could reach and grip the various items while standing on the ground. A simple wire-operated implement was eventually fabricated. The company concerned is Messrs. Carter & Viner of Cooden, Sussex, and as a result of visitors seeing the tool in use, a demand grew up for these 'tongs' for industrial purposes.

With the increased use of radioisotopes, these simple straight manipulators were soon in demand and as the general design had already been well tried, it was only necessary to make certain changes in the materials of construction. All the various types of the wide range of sizes now made have the same basic principle of operation. The claws or

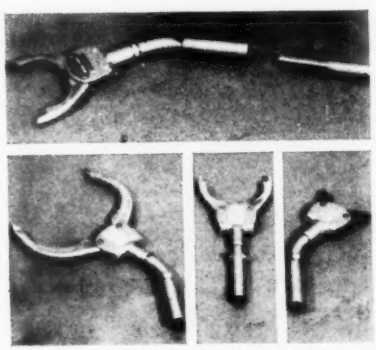


Components of claw head **1.** Jaws; **2.** Jaw pivot; **3.** Jaw springs; **4.** Operating links; **5.** Jaw swivel; **8.** Pull rod; **30.** Bearing housing and **31.** Ball bearing assembly

jaws are operated by a hand grip through a spring-loaded cable, running inside a tube, so arranged that the claws close when the handgrip is clasped. A simple thumb operated locking ratchet is fitted to relieve the grasp if the object it to be held for any length of time in the claws. The sizes of these original types range from 26 in. through 42 in., 60 in., 72 in., to 96 in. in length and can, in fact, be made any length required.

Extending the working facilities

Improvements in this type led to presetting the claw head to any angle required. This in turn led to a unit in which the head can be remotely rotated through 370° from a handwheel located just in front of the hand grip. This rotation is effected through a wire cable running around two small cable drums fitted with ball bearings. The cable is



Interchangeable heads. Three types of claw heads with bayonet fitting for working from one manipulator

limited in its travel to prevent any active or contaminated material being brought within dangerous range of the operator. With this type it is a simple matter to remotely screw or unscrew a nut and bolt or threaded cap.

The claws are individually spring-loaded and compensated—they are made in a variety of shapes to grip any specified shaped object. Normally removable cork liners are fitted to avoid damage to any glassware handled. The ends of the claws have separate recesses to hold small cylindrical items and the extremities are flattened and faced so that it is quite easy to manipulate needles and pins.

Several of these manipulators are in use at the AERE Harwell and a considerable number are used in hospitals and isotope centres at home and abroad.

As the claws and hand grips are standard, differences in length only necessitate changes in length of cables and supporting tube, giving very economic production. So far, the longest manipulator yet produced was in excess of 20 ft and is now in use at Harwell.

One manipulator—several claw heads

Frequently it is desirable for one manipulator to be used in a hot cell handling several different shapes of items and to do this efficiently interchangeable claw heads have been developed. Although still operated by the simple cable/spring mechanism, a bayonet-joint has been introduced just behind the claws, which can be engaged and disengaged from the hand grip. Locating holes on the claw head enable this part of the tool to be located ready for use in any convenient location in the cell.

With the widening uses of isotopes and the necessity to handle highly active materials, a requirement has arisen for the 'over the wall' type of manipulator. Already Carter & Viner have by simple modification produced an efficient yet economical unit of this type, capable of handling items up to 25 lb in weight. Cables are still used for operating, up to the top joint of vertical tube in the hot cell. Rotation is limited to 370° but developments are in hand to make the claw head rotatable not only in the horizontal plane but with vertical movement as well.

These manipulators are normally manufactured with aluminium alloy tubing but stainless steel can be used as an alternative. Like the simple straight manipulators, these tools can be easily produced with any desired lengths, from the hand grip to the top of the wall, distance over the wall and length of tool within the cell all being variable.

New Product Survey

PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

NEUTRON HOWITZER
collimated neutron beams

A new dual-purpose instrument has been announced by Nuclear-Chicago Corporation. Neutron sources may be stored in the unit and can be manipulated safely in it for source transfer or training purposes.

Model NH-2 is also designed for use as a classroom demonstrator. A neutron source can be positioned in the Howitzer at a level with two cadmium-lined ports to produce a collimated neutron beam. A manual supplied with the Howitzer gives detailed instructions on how to perform a variety of nuclear physics and reactor experiments. These include low-order neutron activation studies; fast and slow neutron shielding studies; determination of the radii of various nuclei; and determination of albedos or reflector material characteristics.

Model NH-2 Neutron Howitzer is a 35 × 23 in. diameter aluminium vessel filled with 350 lb of paraffin. The Howitzer is shipped complete with a source-handling tong, two BF_3 detector mounts, and a variety of foils, foil holders and lucite spacers that fit two cadmium-lined port drawers

Tick **No 208** on reply card

MINERAL INSULATED THERMOCOUPLES
small diameters available

British Insulated Callenedr's Cables are now applying the principle of mineral insulation to thermocouple production. The thermocouples consist of two dissimilar thermoelectric conductors, welded together at a point (the hot junction), embedded in highly compressed magnesium oxide insulant, and completely encased in a seamless, circular, stainless steel sheath. They are available in standard overall diameter sizes of 0·122 in. and 0·060 in., but intermediate sizes are also available.

In the standard hot junction the conductors are welded together, and the sheath is welded over to form a hermetic seal completely insulated from the conductors. This does not increase the overall diameter of the cable or make installation any more difficult. For the first time thermocouples of all sizes down to 0·060 in. dia. can be supplied with an insulated junction.

At the other end, the cold end, a seal is fitted to prevent the insulant from absorbing moisture. The seal body is externally threaded to facilitate plain hole entry into junction boxes and instrument casings where it can be held in place by locknuts. The cold end assembly will operate at temperatures up to 150°C. Alternative arrangements at hot and cold ends can be made on request.

A recent addition to the range has been made possible by drawing on established cable manufacturing techniques. By laying up M.I. stainless steel sheathed thermocouples together with stainless steel strands a multiple flexible thermocouple of small overall diameter and high tensile strength is produced.

Tick **No 209** on reply card

AUXILIARY OSCILLOSCOPE
for observation of millimicrosecond waves

Lion Electronic Developments announce an auxiliary unit (the *Nanoscope*) which, when connected with an ordinary laboratory oscilloscope, permits the observation of very fast, repetitive waveforms of the order of a few nanoseconds (10^{-9} second) duration. It has been developed by the Atomic Energy Research Establishment, Harwell, primarily for use with scintillation counters.

It operates by sampling the fast waveform with very narrow pulses at a number of points. This results in the production of a series of pulses, stretched to render them visible on a normal oscilloscope of restricted bandwidth, which are proportional in amplitude to the corresponding ordinates of the sampled waveform. These ordinate pulses are brightened at their peaks, thus tracing the fast waveform as a series of dots on the oscilloscope.

In order that the sampled pulses may be centred on the screen, which shows only a very small period of time in the interval between pulses, means are provided to delay the sampling pulse until the time-base sweeps have started and have reached the appropriate point for the display. Coarse and fine delay adjustments are provided for this purpose. The latter is a helical potentiometer with 1000 divisions, the whole of its range being equal in delay to twice the time-base sweep. Since this can be set to as low as 50 nanoseconds, it follows that each division of the fine delay potentiometer corresponds with 0·1 nanosecond. The instrument is therefore capable of measuring very short intervals in time. The intrinsic rise time of the device is somewhat in excess of 2ns.

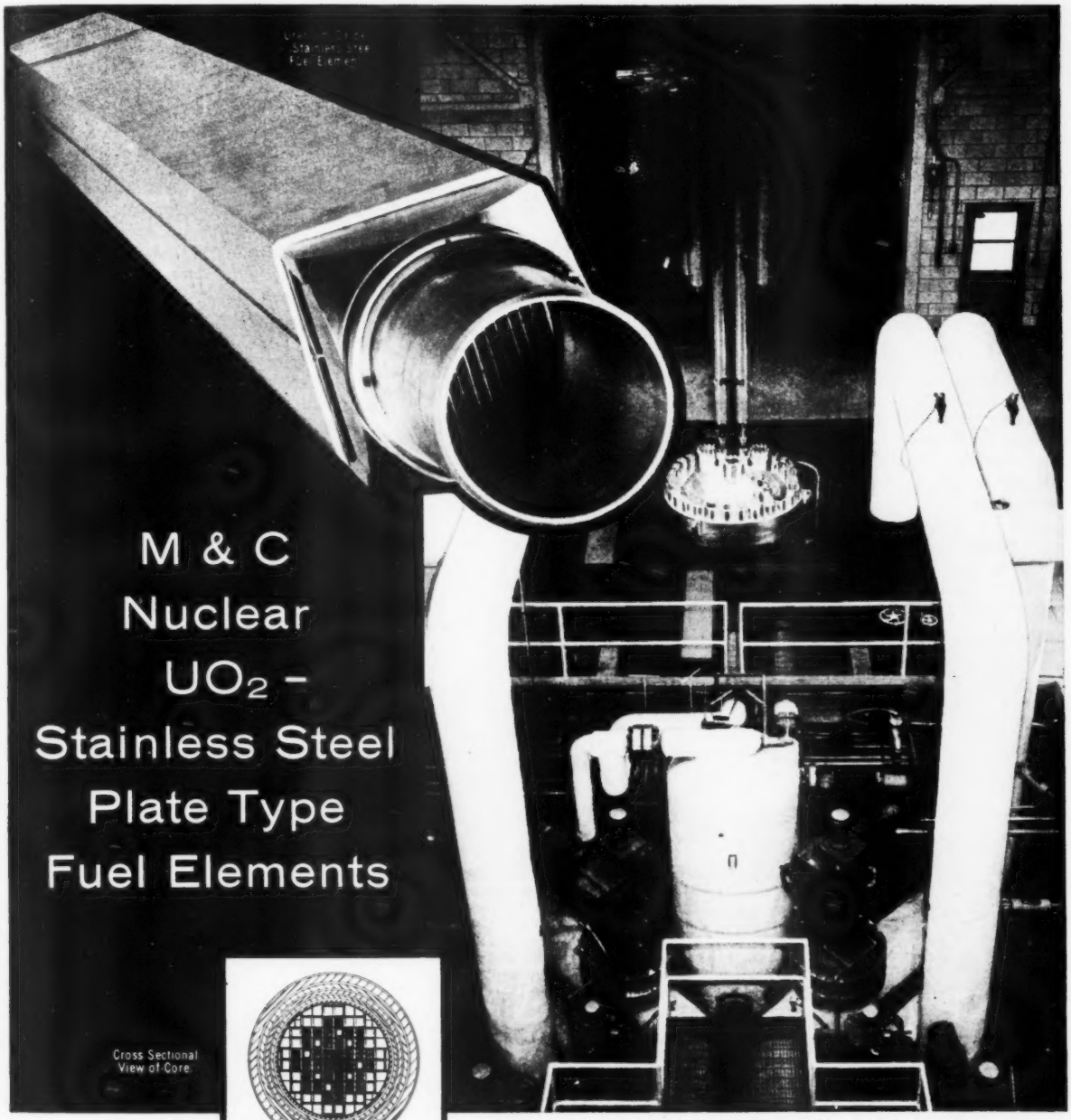
The equipment is provided with a probe which, with range switches on the main unit, gives four settings for input voltages from 0·5 V to 30 V. An internal square-wave generator enables the amplitude of the waveform being examined to be checked to within 5%.

Tick **No 210** on reply card

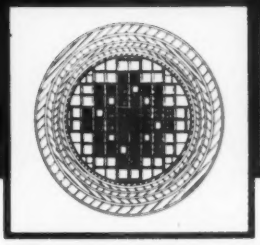
PEAK VOLTMETER
for microsecond pulses

Wayne Kerr Laboratories in collaboration with the UKAEA have developed a 50 kV Peak Voltmeter for the measurement of single or repetitive pulses of 1 microsecond duration or greater. The incoming pulse is applied to a voltage-dividing capacitor network with a ratio of 50:1 and the voltage across the larger capacitor is measured by means of a 0–1 kV electrostatic meter. A level-restoring diode shunts the meter to allow repetitive pulses to be measured. The indicated pulse slowly discharges through an insulation resistance of greater than 10^{15} ohms, the measuring circuit being hermetically sealed to maintain this

The Wayne Kerr peak voltmeter has two ranges: 10 to 50 kV and 5 to 25 kV. The accuracy of measurement is better than ±5% using calibration curves supplied showing initial calibration to irradiated sphere gap to BS 358



M & C Nuclear UO_2 – Stainless Steel Plate Type Fuel Elements



Cross Sectional View of Core

Spert III Reactor, Operated by Phillips Petroleum Co. for the U. S. Atomic Energy Commission.

. . . Used in SPERT-III Reactor

SPERT-III, the second Special Power Excursion Reactor Test facility now in operation at the National Reactor Testing Station, Idaho, will help provide further valuable knowledge of transient behavior of reactors under various conditions of pressure, temperature, and coolant flow.

Phillips Petroleum Company, conceptual designer and operator of SPERT-III for the U. S. Atomic Energy Commission, selected M & C Nuclear to supply the UO_2-stainless steel fuel assemblies for the reactor.

These fuel assemblies are built to withstand unusually severe conditions. Plates are fabricated to exacting specifications and brazed into assemblies with close channel space limitations.

In addition to SPERT-III, M & C Nuclear has produced UO_2-SS cermet plates for two other large reactors. Its modern facilities and technical know-how permit low cost, quality fuel elements to meet every requirement.

Let us assist you in your reactor program by supplying information, working specifications, and designs. Write directly to our Manager of Marketing and Contract Administration.

The fuel plates, illustrated, were manufactured to the following dimensions and specifications.

Fuel Composition	18.8 Weight % UO_2
Length	37.00″ ± .02
Width of Meat	1.431″ ± .003
Thickness-fuel	0.020″ ± .001
Thickness-clad	0.005″ ± .001

M&C NUCLEAR, INC.

P. O. BOX 898, ATTLEBORO, MASSACHUSETTS, U.S.A.

FUEL ELEMENTS. CORE COMPONENTS. COMPLETE CORES

New Product Survey

PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

NEUTRON HOWITZER

collimated neutron beams

A new dual-purpose instrument has been announced by Nuclear-Chicago Corporation. Neutron sources may be stored in the unit and can be manipulated safely in it for source transfer or training purposes.

Model NH-2 is also designed for use as a classroom demonstrator. A neutron source can be positioned in the Howitzer at a level with two cadmium-lined ports to produce a collimated neutron beam. A manual supplied with the Howitzer gives detailed instructions on how to perform a variety of nuclear physics and reactor experiments. These include low-order neutron activation studies; fast and slow neutron shielding studies; determination of the radii of various nuclei; and determination of albedos or reflector material characteristics.

Model NH-2 Neutron Howitzer is a 35 × 23 in. diameter aluminium vessel filled with 350 lb of paraffin. The Howitzer is shipped complete with a source-handling tong, two BF_3 detector mounts, and a variety of foils, foil holders and lucite spacers that fit two cadmium-lined port drawers

Tick **No 208** on reply card

MINERAL INSULATED THERMOCOUPLES

small diameters available

British Insulated Callenedr's Cables are now applying the principle of mineral insulation to thermocouple production. The thermocouples consist of two dissimilar thermoelectric conductors, welded together at a point (the hot junction), embedded in highly compressed magnesium oxide insulant, and completely encased in a seamless, circular, stainless steel sheath. They are available in standard overall diameter sizes of 0·122 in. and 0·060 in., but intermediate sizes are also available.

In the standard hot junction the conductors are welded together, and the sheath is welded over to form a hermetic seal completely insulated from the conductors. This does not increase the overall diameter of the cable or make installation any more difficult. For the first time thermocouples of all sizes down to 0·060 in. dia. can be supplied with an insulated junction.

At the other end, the cold end, a seal is fitted to prevent the insulant from absorbing moisture. The seal body is externally threaded to facilitate plain hole entry into junction boxes and instrument casings where it can be held in place by locknuts. The cold end assembly will operate at temperatures up to 150°C. Alternative arrangements at hot and cold ends can be made on request.

A recent addition to the range has been made possible by drawing on established cable manufacturing techniques. By laying up M.I. stainless steel sheathed thermocouples together with stainless steel strands a multiple flexible thermocouple of small overall diameter and high tensile strength is produced.

Tick **No 209** on reply card

AUXILIARY OSCILLOSCOPE

for observation of millimicrosecond waves

Lion Electronic Developments announce an auxiliary unit (the *Nanoscope*) which, when connected with an ordinary laboratory oscilloscope, permits the observation of very fast, repetitive waveforms of the order of a few nanoseconds (10^{-9} second) duration. It has been developed by the Atomic Energy Research Establishment, Harwell, primarily for use with scintillation counters.

It operates by sampling the fast waveform with very narrow pulses at a number of points. This results in the production of a series of pulses, stretched to render them visible on a normal oscilloscope of restricted bandwidth, which are proportional in amplitude to the corresponding ordinates of the sampled waveform. These ordinate pulses are brightened at their peaks, thus tracing the fast waveform as a series of dots on the oscilloscope.

In order that the sampled pulses may be centred on the screen, which shows only a very small period of time in the interval between pulses, means are provided to delay the sampling pulse until the time-base sweeps have started and have reached the appropriate point for the display. Coarse and fine delay adjustments are provided for this purpose. The latter is a helical potentiometer with 1000 divisions, the whole of its range being equal in delay to twice the time-base sweep. Since this can be set to as low as 50 nanoseconds, it follows that each division of the fine delay potentiometer corresponds with 0·1 nanosecond. The instrument is therefore capable of measuring very short intervals in time. The intrinsic rise time of the device is somewhat in excess of 2ns.

The equipment is provided with a probe which, with range switches on the main unit, gives four settings for input voltages from 0·5 V to 30 V. An internal square-wave generator enables the amplitude of the waveform being examined to be checked to within 5%.

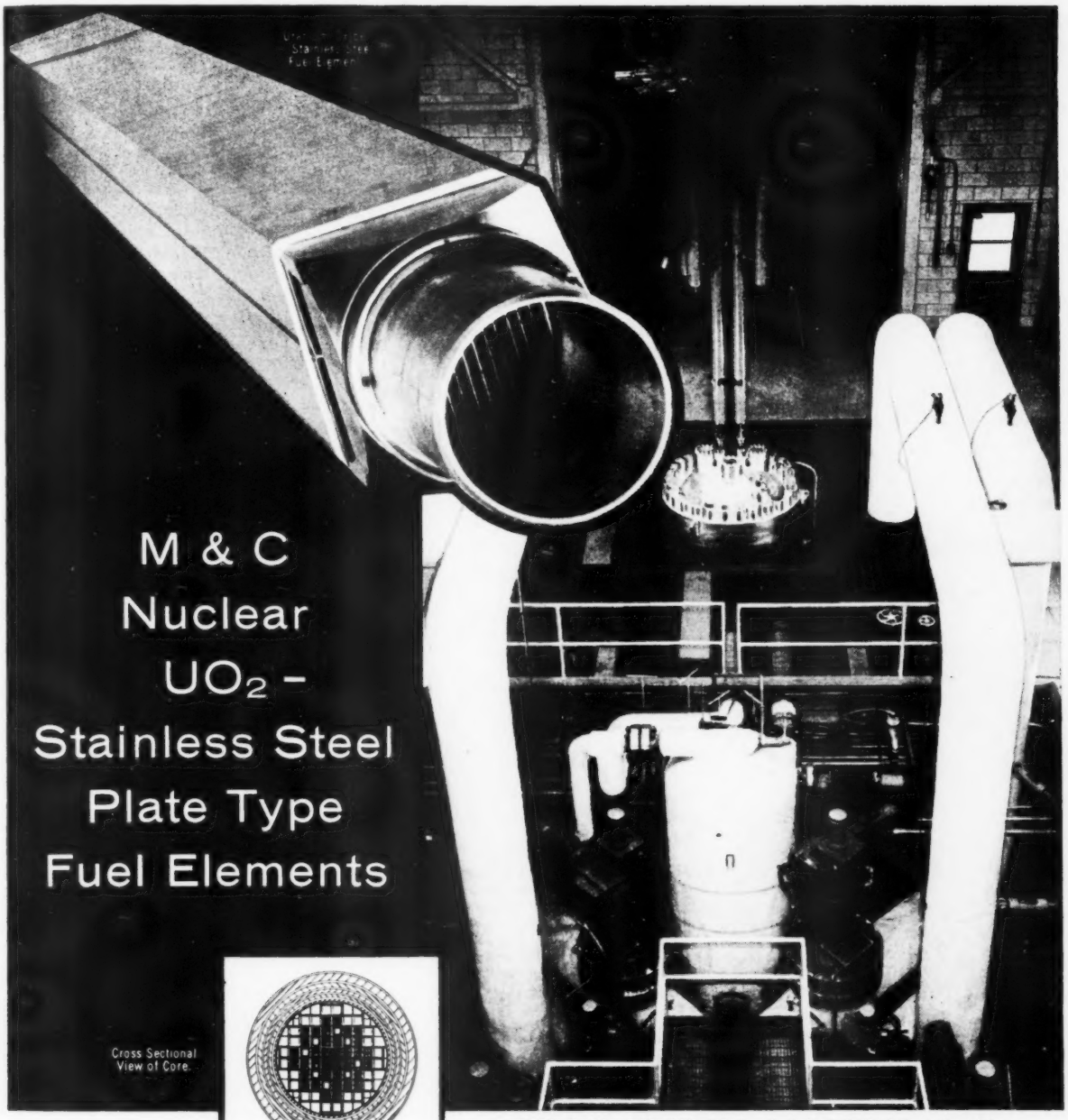
Tick **No 210** on reply card

PEAK VOLTMETER

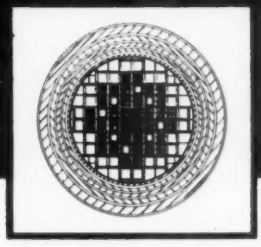
for microsecond pulses

Wayne Kerr Laboratories in collaboration with the UKAEA have developed a 50 kV Peak Voltmeter for the measurement of single or repetitive pulses of 1 microsecond duration or greater. The incoming pulse is applied to a voltage-dividing capacitor network with a ratio of 50:1 and the voltage across the larger capacitor is measured by means of a 0–1 kV electrostatic meter. A level-restoring diode shunts the meter to allow repetitive pulses to be measured. The indicated pulse slowly discharges through an insulation resistance of greater than 10^{15} ohms, the measuring circuit being hermetically sealed to maintain this

The Wayne Kerr peak voltmeter has two ranges: 10 to 50 kV and 5 to 25 kV. The accuracy of measurement is better than ±5% using calibration curves supplied showing initial calibration to irradiated sphere gap to BS 358



M & C Nuclear UO_2 - Stainless Steel Plate Type Fuel Elements



Cross Sectional View of Core.

Spert III Reactor, Operated by Phillips Petroleum Co. for the U. S. Atomic Energy Commission.

. . . *Used in SPERT-III Reactor*

SPERT-III, the second Special Power Excursion Reactor Test facility now in operation at the National Reactor Testing Station, Idaho, will help provide further valuable knowledge of transient behavior of reactors under various conditions of pressure, temperature, and coolant flow.

Phillips Petroleum Company, conceptual designer and operator of SPERT-III for the U. S. Atomic Energy Commission, selected M & C Nuclear to supply the UO_2-stainless steel fuel assemblies for the reactor.

These fuel assemblies are built to withstand unusually severe conditions. Plates are fabricated to exacting specifications and brazed into assemblies with close channel space limitations.

In addition to SPERT-III, M & C Nuclear has produced UO_2-SS cermet plates for two other large reactors. Its modern facilities and technical know-how permit low cost, quality fuel elements to meet every requirement.

Let us assist you in your reactor program by supplying information, working specifications, and designs. Write directly to our Manager of Marketing and Contract Administration.

The fuel plates, illustrated, were manufactured to the following dimensions and specifications.

Fuel Composition	18.8 Weight % UO_2
Length	37.00″ ± .02
Width of Meat	1.431″ ± .003
Thickness-fuel	0.020″ ± .001
Thickness-clad	0.005″ ± .001

M&C NUCLEAR, INC.

P. O. BOX 898, ATTLEBORO, MASSACHUSETTS, U.S.A.

FUEL ELEMENTS. CORE COMPONENTS. COMPLETE CORES

Tick **No 65** on reply card for further details

figure. Discharge can be obtained by pressing a button on the front panel which operates a relay within the sealed compartment.

Tick **No 211** on reply card

RADIATION SHIELDING

barytes and iron loaded bricks

Unibrix radiation shielding have introduced a new range of interlocking, portable, high density shielding bricks. Precision made, and of uniform weight and size the bricks can easily be assembled by unskilled labour. Two grades of material are available—Unibrix PB, based on barytes, and Unibrix IR, based on iron.

Already being supplied to the UKAEA, Unibrix can be used for most shielding applications due to the shape and high crushing strength of the bricks walls of considerable height can be erected. Weight varies within 15–30 lb so no mechanical lifting devices are necessary.

It is not easy to calculate accurately the optimum thickness of a shielding wall owing to the number of factors involved,

Unibrix octagonal shield for source safes, shielding around ducts, apparatus, etc. There are nine different shapes of brick, allowing for all combinations for building walls, permitting the erection of completely interlocking corners of 90° and 135°

such as type, shape and strength of the source, energy spectrum, distance from shielding, amount of back-scattering and so forth. To obtain an approximation the following relations can be used, but the second is very pessimistic for thicknesses above a few inches:

1. $R = 7EC$
2. $A = 10^{T/TVL}$

where R = roentgens/h at 1 ft. E = energy in MeV, C = curies. A = attenuation, T = wall thickness and TVL = tenth value layer of the appropriate metal (i.e. that material thickness required to reduce the radiation level by one tenth).

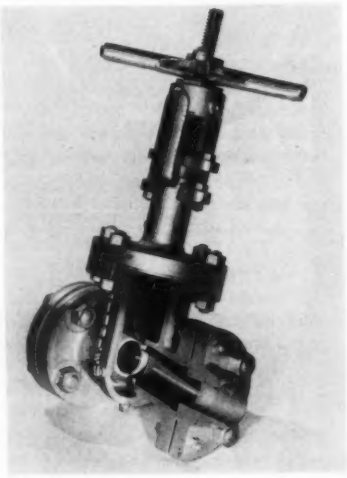
Accessory products from the makers are high density barytes cement for use with permanent structures and high density lead glass windows and sphere units. The latter can be supplied to specification and may be fitted flush into the wall, thus avoiding expensive frame construction.

Tick **No 212** on reply card

LEAKPROOF VALVE

fluon seated

To meet the need for a leakproof gate valve, Joshua Hindle Ltd. have introduced an interestig new fluon-seated model. Known as the Hindle-Hamer H15, it has a double sealing action: it addition to the metal-to-metal fit of the



Alterations in the angular and distance relationships of the two seat faces due to line stresses and varying pressure and temperature conditions occur in all conventional gate valves, but in the case of the Hindle-Hamer leakproof gate valve any such movement is absorbed by the fluon rings and the valve remains sealed

wedge against the valve seats, two fluon seals contained by stainless steel sleeves which extend through the full length of the bore of the valve, are compressed against the wedge as it is lowered. As a check, the bonnet is tapped and plugged, permitting the installation of a tell-tale bleeder, an arrangement which incidentally gives visible proof that the valve seals positively on the upstream face.

Ordinary gate valves suffer serious and cumulative wear on their wedge and seat surfaces, particularly when corrosive fluids are being handled. This particular problem cannot arise using fluon seats, because it is unaffected by most known chemicals and its plastic flow quality enables it to completely contain any solids which normally score metal seats and cause 'passing.' Made in carbon steel and stainless steel, this valve is recommended by the makers for 'tough-spot' applications, wherever and whenever a really positive shut-off is required.

Tick **No 213** on reply card

IN BRIEF

Furnaces and heaters. Electrothermal Engineering have produced a new armoured heater for stress-relieving welds and other forms of heat treatment. They also announce a new flexible surface heater for working temperatures of up to 1000°C.

Tick **No 214** on reply card

Barrel pump. Another air-operated portable barrel pump has been added to the British Central Electrical company's range. This high efficiency air motor is self-priming and will operate against full pressure. It will handle most liquids and deliver up to 2000 gal/h dependent on viscosity and lifting head.

Tick **No 215** on reply card

Self-sealing coupling. Exactor's new pressure balance coupling allows for quite large couplings to be connected with ease at comparatively high pressures. It is claimed that a 3 in. pipe was coupled without undue effort when the pressure in the lines was 400 lb/sq in.

Tick **No 216** on reply card

Thermocouple wire. A miniature thermocouple wire with an outside diameter of only 0·5 mm is the latest addition to the *Thermocoax* range by Research and Control Instruments. Known as the Thermocoax 2AB Ac 05, it has an outer sheath of 18/8 steel and cores of Chromel/Alumel insulated from each other and the sheath by powdered magnesium oxide.

Tick **No 217** on reply card

Stud welder. New equipment for use with standard arc welding transformers and mild steel studs of $\frac{3}{16}$ in. to $\frac{1}{4}$ in. dia. have been introduced by the Stud Welding Applications Company. The pistol-type hand tool weighs only $2\frac{1}{2}$ lb and is fitted with a new type of locating foot for precise positioning of studs vertical to the workpiece. Controls are contained in a single unit fitted with arc or stud welding selector switch.

Tick **No 218** on reply card

Molybdenum disulphide paste. Moly-Paul's new general purpose paste 100 has many uses. As well as the usual anti-scuffing and anti-seizing applications, it is also suitable as a running-in paste, a first-aid material, and a tapping and drilling compound for stainless steels and other difficult materials.

Tick **No 219** on reply card

Can we help you with your pipe problems?

Expansion, contraction and lateral movement of pipe work under extreme conditions of temperature and pressure is no problem to the engineer who has been wise enough to contact and consult TEDDINGTON technicians.

Teddington Bellows Expansion Joint cylinders are butt-welded from highly finished cold rolled stainless steel sheet. Convolutions are introduced to give the bellows their characteristic flexibility. Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joint. Wherever pipework is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

SEND FOR BROCHURE No. R 67

Teddington Bellows are produced in technical collaboration with the Solar Aircraft Co., U.S.A.

TEDDINGTON BELLOWS

EXPANSION JOINTS

TEDDINGTON AIRCRAFT CONTROLS LIMITED, (*Industrial Bellows Division*)
Ammanford, Carmarthenshire. Tel: Ammanford 2255

Tick **No 66** on reply card for further details

INDUSTRIAL NEWSDESK

1959 Power Convention discuss nuclear energy

The eleventh British Electrical Power Convention and Exhibition was held from June 1 to 5, at Torquay. The theme of the proceedings, attended by some 1500 delegates, was 'Electricity and It's Contribution to the Standard of Living' - one of the five papers covered the progress of the four nuclear power stations now under construction. This paper, by Mr. F.H.S. Brown, a member of the CEGB, and Mr. J. Henderson, chief engineer of the SSEB, stressed that 'the design of a nuclear power station must be such that not only does the final result form a coherent workable and economic generating unit, with a load factor of at least 85% throughout its life, but also be such that the station can be constructed rapidly and economically. Not only are capital costs reduced by a design which permits a logical sequence of construction, but the money expended in construction is not productive until the station becomes operational. This is not always recognised by engineers whose interests are not primarily concerned with power stations.'

Points raised during the discussion included the view that greater use should be made of consulting engineers' services in nuclear power station design and that goliath cranes were not only the best method of erection : they also simplified the installation of the fuelling machinery.

Lifting itself by its own bootstraps. Taking only a little over one hour and using its own hoisting gears, the 250ft bridge of the world's largest Goliath crane was lifted into its final position 235ft above the ground at Hinkley Point. Babcock & Wilcox Ltd. will also supply a similar type of crane for the Trawsfynydd Power Station project. (see Worldview, this month)

The associated exhibition showed the products and activities of some forty companies and organizations - the equipment ranged from a Bristol Siddeley 3MW turbo-generator to all types of cables and domestic appliances. In addition to delegates, their friends and trade associates, over 25,000 people visited the exhibition during the time, totalling two days, it was open to the public.

At the forum concluding the convention, Sir Christopher Hinton, chairman of the CEGB, said Britain was now moving into a three-fuel economy - coal, oil and nuclear power - the evolution of which would present many difficulties and that the perfect economic balance would take a long time to reach.

Expanding US overseas trade

A new company, Nuclear Equipment Ltd., has been set up jointly by General Mills Inc., of Minneapolis, and Savage & Parsons Ltd., of Watford, to specialize in the design, manufacture and marketing of remote-controlled nuclear handling apparatus. While, with the exception of the US, it will maintain close contact with nuclear establishments throughout the world, its prime interests will be the British Commonwealth and Western Europe.

Joy-Sullivan Ltd., the wholly-owned subsidiary of the Joy Manufacturing Co., of Pittsburgh, has set up an Air Power Division. This unit will be responsible for the manufacture in the UK of a wide range of compressors and compressed air tools for civil engineering, quarrying and metal mining industries.

More quit AEA

Mr. W.B. Hall, deputy chief scientific officer at Windscale, is to leave the Authority shortly to become the first occupant of the newly-created chair of nuclear engineering at Manchester University. Also leaving the Authority is Mr. D.H. Hill of the Industrial Group, who has been appointed resident nuclear energy attaché to Mr. A.H. Tandy, the UK's representative to Euratom.

The chief of nuclear research at Aldermaston, Dr. S.C. Curran is to succeed Sir David Anderson as principal of the Royal College of Science and Technology, Glasgow. Dr. Curran, who is 47, was largely responsible for the development of the scintillation counter.

UK and USA announce more training schemes

Twelve American colleges and universities are to receive grants totalling $251,704. - They are the first part of AEC's new programme of assistance for education and training in radioisotope principles and technology. The second session of two specialized courses in reactor technology will begin on November 2 at AEC's Oak Ridge National Laboratory. These, 'Nuclear Reactor Operations Supervision' and 'Nuclear Reactor Hazards Evaluation,' run for 9 and 12 months respectively.

The UK Atomic Energy Authority will start its 19th standard reactor course on August 31 and continue un-

new EKCO Thermocouple Trip Amplifier

SPECIFICATION

Operational Trip Setting. 0-250°C.

Trip Margin Meter Indication. Up to 100% of trip temperature.

'Low-Margin' Trip. May be set anywhere within the available trip margin range.

Trip Accuracy. 0.4% of trip temperature. This accuracy is maintained if the range is extended above 250°C.

'Low-Margin' Trip Accuracy. Better than 2% of the meter range. (Accuracy limited because the meter is used for setting).

Hysteresis and Stability of Both Trips. 2% of meter range.

Input Signal Required. 40 μV/°C.

Thermocouple Earthing. Can be at either terminal or at the hot point. (The amplifier is isolated from earth).

Stability. Cold junction compensation ensures that performance remains within the limits specified up to 40°C. ambient temperature. Performance is unaffected by mains variations of ± 10%.

Thermocouple Resistance. Up to 250 ohms for performance specified. Up to 500 ohms for ambient temperature ('cold junction') up to 30°C.

Response Time. Less than 0.2 seconds.

Recorder Output. A 100 mV recorder can be driven to indicate the meter reading at an impedance of 100 ohms.

Dimensions. Front panel 4" wide x 8¼" high. Depth 13".

Mains Input. 110-120v or 200-250v A.C., 45/60 c/s.

Mains Consumption. 20 watts approximately.

Type N642 A

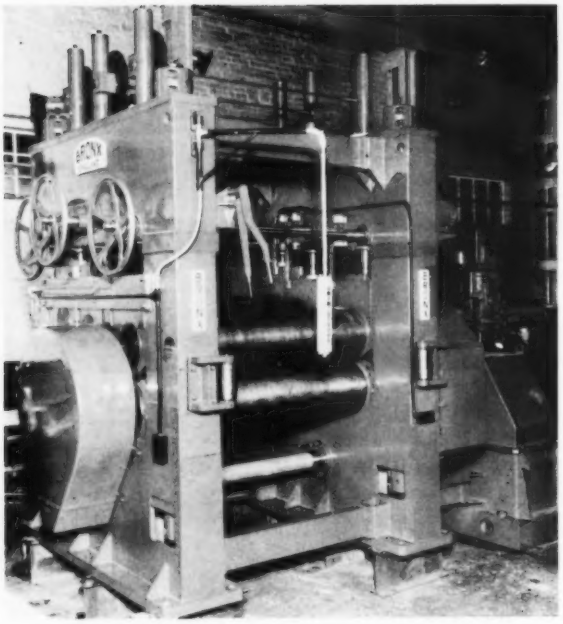
The Ekco range of reactor instruments also includes the following:—

Reactor Period Meters with alternative ranges.
Reactor Power Error Meter.
Resistance Thermometer Trip Unit.
Shut-Down Amplifier (with start-up facilities and shut-down state trip).
Fast Neutron Monitor (installed).
Misalignment Indicator (for coarse control arms.)
Leak Indicator (for external heavy water leak).
Effluent Monitor.
Battery Box Assemblies.
Logarithmic Gamma Health Monitor (installed).
Slow Neutron Survey Meter (portable).
Beta-gamma Survey Meters (portable).
Decade Voltage and Current Generator (general purpose test unit).
Reactor Period Meter Test Unit.

EKCO ELECTRONICS LIMITED

SOUTHEND-ON-SEA · ESSEX · Telephone: Southend 49491

Tick **No 67** on reply card for further details



Levelling and straightening. This new model Bronx heavy duty plate rolling mill has been delivered to John Thompson Ltd. at Wolverhampton. The machine is capable of levelling and straightening plates up to 4in. thick and the arrangement of the rolls is such that the operator has complete control over the plate while it is being worked

til December 18, at the Harwell Reactor School. The 9th special course for Senior Technical Executives will be held from September 21 to October 1

Preliminary plans to train radiation hazards specialists and extend the knowledge of dealing with radioactivity have been announced by the AEA. These have been based upon two interim reports by the Veale Committee - the first recommends special post-graduate courses in the field of radiological health and safety and it is expected that two courses will be held this autumn at London University - the second report proposes a summer school for people who, although not engaged on full time health and safety duties, need some knowledge of the problems involved. Sponsored by the Oxford Extra-Mural Delegacy and the AEA, this course will be held in August at New College, Oxford. The final report from the Veale Committee is expected later this year when consideration will be given to the question as to whether a national training centre is desirable or not.

Getting inside Europe

Two British companies announced plans during June which will enable them to take a more active part in the European Common Market. Ekco Electronics Ltd. have formed a new company in Italy, to be known as Ekco Nucleare Italiana. It will facilitate nuclear instrumentation for reactors, industrial instrumentation and the sale of nucleonic and research development instruments.

A new associate company of the Solartron Electronic Group Ltd. is Solartron France S.A. and already negotiations are in hand for a French manufacturer to make certain types of Solartron precision electronic equipment. This new Anglo-French company will link up with Solartron companies in Germany, Italy, Netherlands and Sweden to give pan-European sales and technical service coverage.

US step up aircraft reactor facilities

During June, the US Atomic Energy Commission placed contracts totalling rather more than one and a half million dollars for services in the Aircraft Nuclear Propulsion Area and Flight Engine Test Facility at the National Reactor Testing Station, Idaho. The work included a technical service laboratory ($400,000) ; exhaust duct and stack system ($439,559) ; roadwork ($231,690) ; and the installation of instruments ($495, 000). The installation contract covers data and control systems, closed circuit television, weather, radio communication, area radiation monitoring, data reduction, rupture detector and stack gas monitor systems.

Major American take-over

Allis-Chalmers Manufacturing Co., of Milwaukee, have purchased the Commercial Nuclear Reactor Engineering Office, Washington DC., of Nuclear Products - Erco Division of ACF Industries Inc. ACF's contractual obligations include the Elk River power reactor, the Wright-Patterson Air Force Base research reactor and the Swedish and Dutch reactor projects now in hand. These contracts are valued at approximately $M10. The present organization in Washington will be maintained and will become part of Allis-Chalmers' Atomic Energy Division. ACF will concentrate its nuclear energy activities in its Albuquerque division, which operates one of the larger facilities of the AEC's weapon production facilities.

International Exhibitions and Trade Shows

ENGLAND. On June 11 a mobile exhibition unit was brought into use by the Lancashire Dynamo Group. This unit which houses a typical cross section of the products of the Rugeley works will visit a large number of centres in England and Scotland and it is anticipated that in future years, it will ultimately travel to the major industrial centres on the Continent.

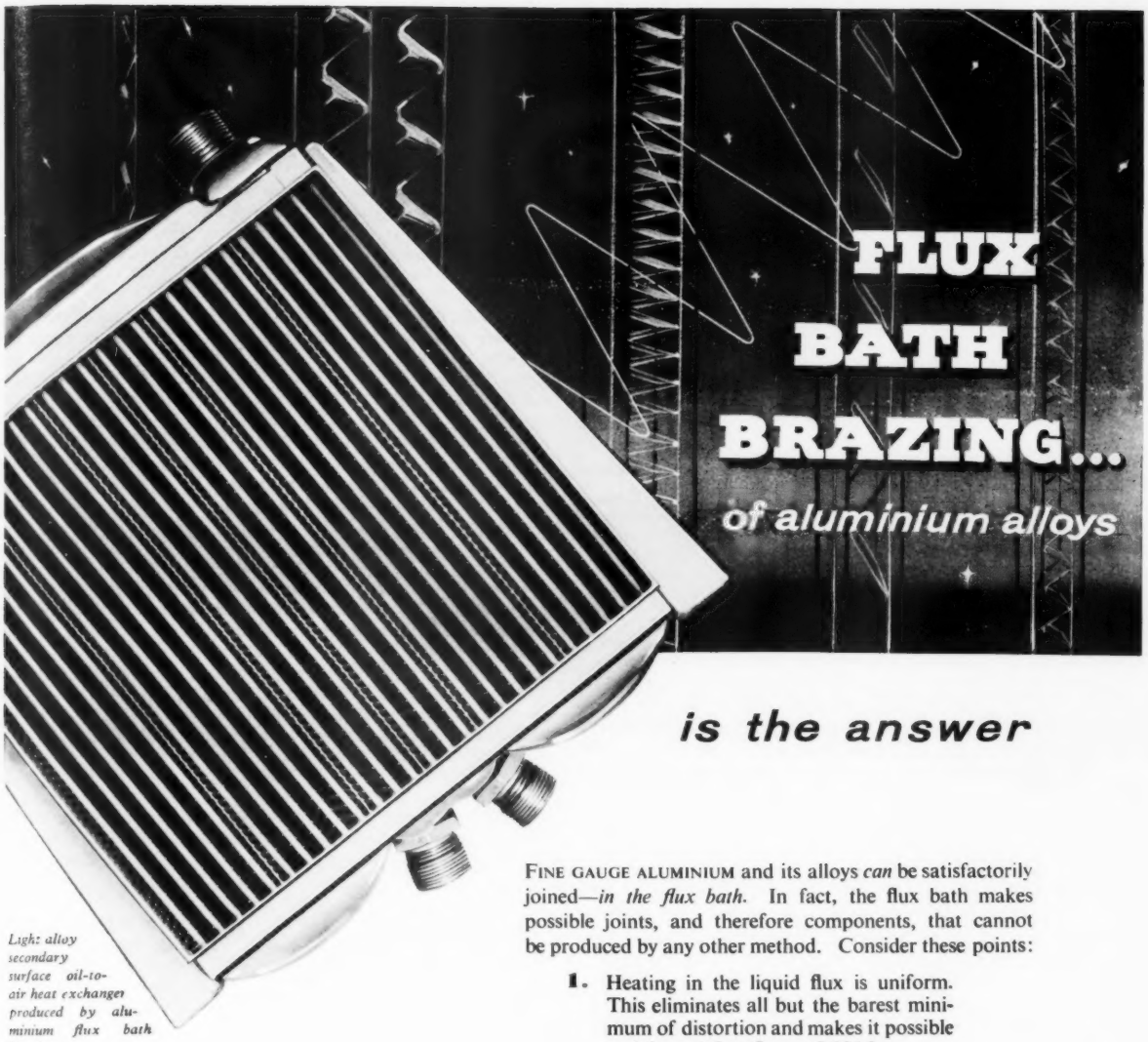
ENGLAND. The 14th Annual Electronics Exhibition and Convention will be held from July 9 to 15, at the College of Science and Technology, Manchester. Among the exhibits of interest to nuclear engineers, are a number of new industrial X-ray machines.

GERMANY. Apart from the UK Atomic Energy Authority, thirteen British manufacturers will be showing at the 9th International Congress and Exhibition of Radiology which will take place at Munich between July 23 and 30.

SCOTLAND. The Scottish Industries Exhibition will be held at the Kelvin Hall, Glasgow between September 3 and 19. It is anticipated that the model of Babcock & Wilcox's nuclear marine project for the Galbraith Committee will be amongst the exhibits.

FRANCE. Automatic and remote control systems will be emphasized at the 6th European Machine Tool Exhibition which will be held in Paris, from September 12 to 21.

ENGLAND. The Pneumatics and Hydraulics for Industry Exhibition and Convention which was to have been held in October, 1959, has now been absorbed into the 1st International Compressed Air and Hydraulics Exhibition and the 2nd European Fluid Power Conference which will be held between April 25 and 29, 1960, at Olympia, London.



FLUX BATH BRAZING...

of aluminium alloys

is the answer

Light alloy secondary surface oil-to-air heat exchanger produced by aluminium flux bath brazing.

FINE GAUGE ALUMINIUM and its alloys *can* be satisfactorily joined—*in the flux bath*. In fact, the flux bath makes possible joints, and therefore components, that cannot be produced by any other method. Consider these points:

1. Heating in the liquid flux is uniform. This eliminates all but the barest minimum of distortion and makes it possible to join metal as fine as 0.006 in.
2. Any number of inaccessible joints can be designed with complete confidence.

These two simple statements reveal a whole new field of opportunity for designing in aluminium and aluminium alloys—but, naturally, a certain 'know-how' is required.

We have this 'know-how.' If you are interested in using it, please consult us. We shall be equally happy either to design for you or co-operate with your own designers.

We are specialists in heat exchange, heat insulation, and all types of brazing and welding.

Delaney Gallay LTD

VULCAN WORKS, EDGWARE ROAD, LONDON, N.W.2
TELEPHONE: GLADSTONE 2201

The world's largest pressure vessel to be pneumatically tested. During June 6 & 7, the first of the two reactor vessels at Berkeley was air tested at 211 lb/sq in. Preparations shown include the sealing off of all outlets and the extensive strain gauge installation. Prior work included the radiography of some 2500ft of weld and stress relieving at 575-650°C

Mainly discussions

RISO. An international health physics symposium, jointly organized by the OEEC European Nuclear Energy Agency and the Danish Atomic Energy Commission, was held at the Danish centre from May 25 to 28. Over 100 participants from fifteen countries took part and the lectures covered all aspects of radiation measurement and means of controlling contamination.

GATLINBURG. At the American Nuclear Society's national meeting between June 15 and 17, over 1100 scientists, 65 US organizations and 3 foreign governments cooperated in presenting some 200 technical papers. Particular attention was given to recent criticality accidents, reactor safety standards and fuel reprocessing.

CAMBRIDGE. The 1959 Convention of the British Institution of Radio Engineers held at the Cavendish Laboratories, July 1 - 4, reviewed 'Television Engineering in Science, Industry and Broadcasting.' Among the papers presented, reviews of closed circuit television for the examination of nuclear reactors and methods of intensifying X-ray images to permit lower radiation, were included.

WARSAW. The IAEA are holding an International Conference in Warsaw, from September 5 - 11, 1959, on the Application of Large Radiation Sources in Industry. This will be the first international meeting to be held on the subject and will emphasize radiation applications to industrial chemical processes.

LONDON. Advanced information has been issued by the Institution of Mining and Metallurgy covering the Fifth International Congress on Mineral Processing, which will be held at Church House, Westminster, from April 6 to April 9, 1960.

MOSCOW. The First International Congress for Automatic Control will be held from June 25 to July 5, 1960, and is being organized by the National Member Organizations of the International Federation of Automatic Control.

In Brief

HUNTERSTON'S T.V. A contract, worth £50,000, for several different types of special-purpose camera has been awarded to Pye Ltd. This order is the first part for equipment covering the closed circuit monitoring system.

BRITISH DENSITY GAUGE ORDER. The Iraq Petroleum Co. Ltd. have ordered nine of Ekco's new Nucleonic fluid density gauges. They will be used on the 555 miles of pipeline between Kirkuk and Tripoli and will monitor the location and extent of the interface between different oils to prevent contamination of the higher density oils on arrival at the storage tanks.

FALL OUT MONITOR FOR EVERYONE ? The American AEC have placed a contract with Tracerlab Inc. to make 24 Banshee-equipped radios of various types for an AEC evaluation study. The Banshee is a thumb-sized plug-in radiation alarm which causes any radio or television set to emit a wailing sound in the presence of harmful radiation. It is anticipated that the device could be sold for about $5.

NEW REACTOR FUEL LABORATORY. The Vitro Engineering Co. have been awarded a contract to design a $M3 laboratory for the AEC at Oak Ridge National Laboratory. This will provide experimental data for the development of plutonium and other new reactor fuels.

NRDC SUPPORT FOR COMPUTER DEVELOPMENT. Two high-speed computer manufacturers, Ferranti Ltd. and EMI Electronics Ltd are to be supported by the National Research Development Corp. (NRDC), in further development work on advanced high speed computers.

ENCOURAGING NUCLEAR STANDARDS. An Institute of Nuclear Materials Management has been formed in Pittsburgh to establish and encourage the use of prescribed standards in the management of nuclear materials and to certify qualified individuals in this field.

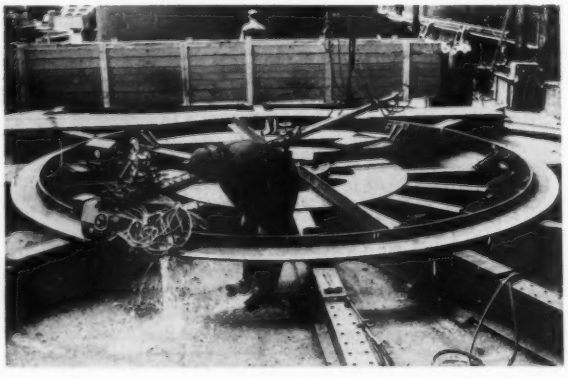
TRANSFORMERS DELIVERED TO BERKELEY. The first two of the four 100MVA 11.8/141.6-kV units have been completed by British Thomson-Houston and despatched to site. These generator transformers are for direct connextion between turbo-alternators and 132-kV grid.

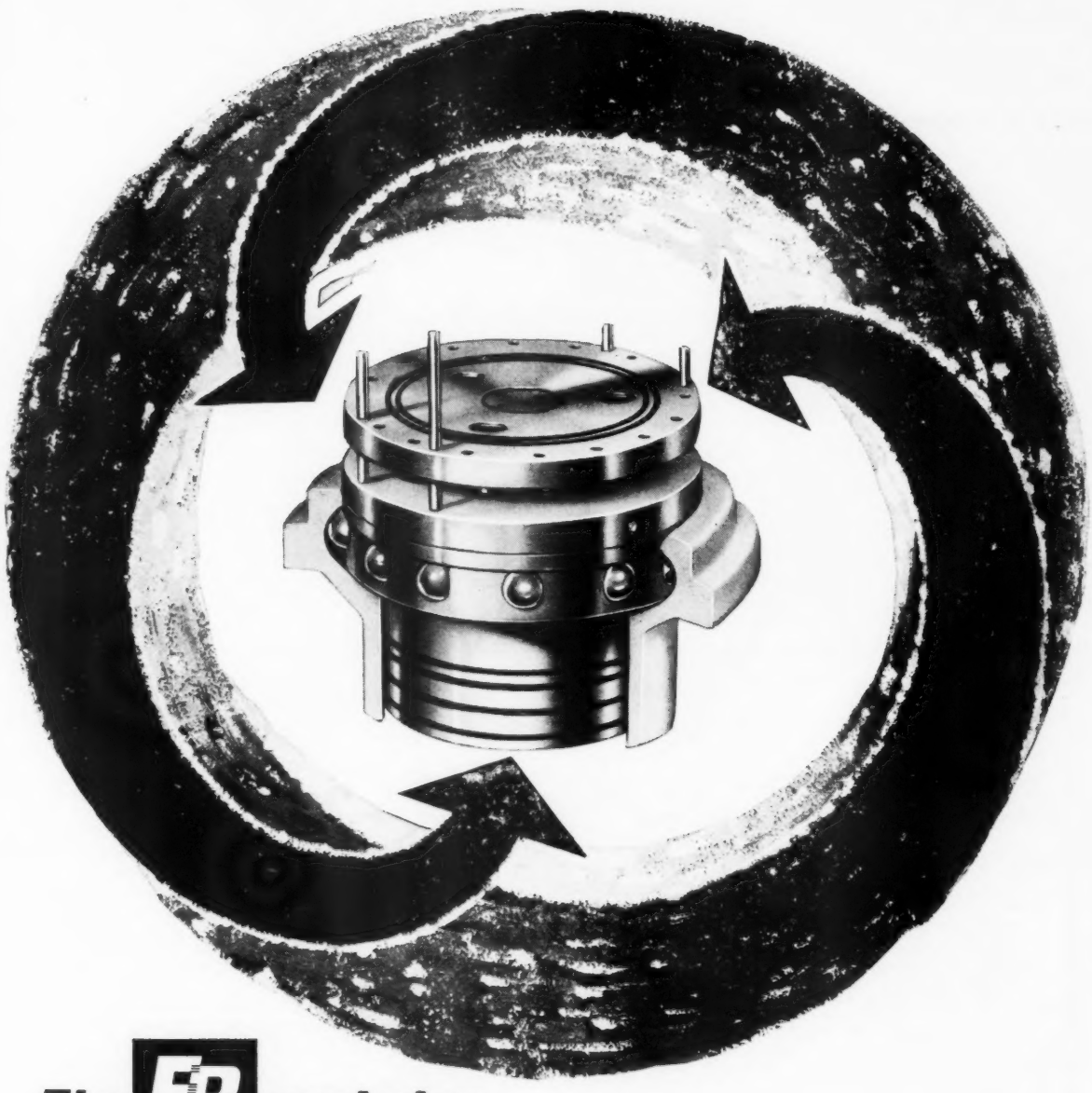
RESEARCH CONTRACT AWARDED. The Bettis Atomic Power Plant has awarded a contract to Controls for Radiation, Inc. for a number of radioanalyses of corrosion products and fission products in nuclear reactor coolants.

VACUUM PUMPING EQUIPMENT. As a result of the increased use of double walled storage vessels for liquid oxygen, nitrogen, argon and methane, Edwards High Vacuum Ltd. have developed special mobile pumping units to evacuate these vessels interspace.

MOBILE SODIUM MELTING STATION. Atomics International have designed and built a portable unit to eliminate the need for stationary melting stations on field test facilities. It is complete with heaters, nitrogen-operated pressure filter tanks and instrument console.

British Oxygen Gases Ltd. To speed building of nuclear sub 'Dreadnought', designed, developed and completed in seven weeks from receipt of order is this special purpose circle cutting machine. Self-propelled and carrying a five-nozzle head, it is used for flame cutting the transverse hull sections





The FR seal plug

The FR Standpipe Seal Plug, the design of which is backed by several years of testing and research and covered by world patents, has been adopted by every major nuclear energy design group. Its main advantages are as follows:

1 Suitability for any reactor fluid and any reactor temperature or pressure.

2 Top, bottom or side mounting.

3 Can be mounted in any radial position.

4 Fitted or removed simply by lowering or lifting and hence this operation is extremely rapid.

5 Can be provided with clearbore holes for flux scanning, control rod drives, etc.

6 A pressure lock prevents plug being removed until pressure is equalised above and below (e.g. reactor blown down or pile-cap machine coupled and pressurised.)

7 A mechanical lock prevents plug being lifted until grab is correctly secured to plug lifting attachment.

The Company would be pleased to draw up specifications of Seal Plugs to meet any given problems.

Flight Refuelling Ltd

Tarrant Rushton Airfield, Blandford, Dorset. Telephone: Blandford 501. Telegrams: Refuelling, Blandford

Also at Ringwood Road, West Howe, Bournemouth, Hants. TA 2385

Tick No 262 on reply card

BOOK SERVICE

All the books reviewed in *Nuclear Power*, and all other scientific and technical books and periodicals from all over the world may be obtained from:—

BLACKWELL'S
BROAD STREET
OXFORD

Get all the
latest information
from our catalogues of new books on
Science
and
Technology

free on request

NEW BOOKS
on Atomic and Nuclear Physics

(General, Advanced and Applied) Supplied from stock. Foreign books not in stock obtained to order. Catalogues on request.

SECOND-HAND BOOKS

A constantly changing large stock of Scientific and Technical Literature on view, classified under subjects.

LENDING LIBRARY
Technical and Scientific

Annual Subscription from £1 . 17 . 6. Bi-monthly list of New Books and New Editions sent post free to all subscribers on request. Prospectus post free on application.

H. K. LEWIS & CO. LTD
136 Gower St. W.C.1. EUS 4282

Tick No 263 on reply card

Book Reviews

A must

Proceedings of the Sixth Scintillation Counter Symposium Special Number, Institute of Radio Engineers Transactions on Nuclear Science New York 1959: 146 pp $7.50 (to IRE members $3.50)

The scintillation counter is gradually extending its role of usefulness and the succession of symposia conventions dealing with this important component and its applications is a fair indication of the interest of designers and users of nuclear instruments in this subject. The present volume contains an account of the latest developments in photomultipliers, scintillating media and counters based on combinations of the two. The thirty-three papers presented constitute a valuable summary of the present position on scintillation counting which is not available elsewhere. The biennial symposium was held on this occasion in Washington DC, and it is significant that a substantial number of workers from outside the United States attended. The symposium, for example, included three papers by authors from this country.

The subjects covered included researches on scintillators, status reports on photomultipliers from the various companies marketing these components, descriptions of several types of spectrometer using scintillation counter techniques with details of their performance and discussion of their suitability for different types of measurement discussion of applications where very high sensitivities are necessary (e.g. gamma-ray detection in humans) and where high counting rates are involved. One of the most interesting contributions for the readers of NUCLEAR POWER is the paper by W. W. Marrigan on 'Application of scintillation counters to reactors', which discusses particularly the use of gamma-sensitive scintillators to low-power training reactors and reactor critical experiments where the residual fission fragment gamma activity is kept low.

The author compares some results obtained with such detectors in linear and logarithmic counting channels with those obtained using conventional neutron sensitive counters and ion chambers. One advantage found is the reduction in the time required to sense an unsafe condition.

There are also a number of papers discussing the auxiliary equipment required, e.g. pulse amplifiers, pulse-amplitude analysers, time sorters, etc., and there is considerable mention of the use of transistor circuits in such equipment.

Another paper of special interest is that by R. B. Murray who discusses the use of $Li^{6}I$ (Eu) as a fast neutron detector. The principal advantage of this component is its relatively high detection efficiency, which according to the author, may be of orders of magnitude greater than the usual recoil proton detectors. The chief advantages are the necessity of careful selection of crystals and the inconvenience of low temperature operation. It is interesting to note that the actual operating temperature used is largely detected by the fact that conventional photomultipliers fail to operate below about $-140°C$.

Well printed, with clear and accurate drawings, this is a book which every serious student of scintillation counting must possess.

Denis Taylor

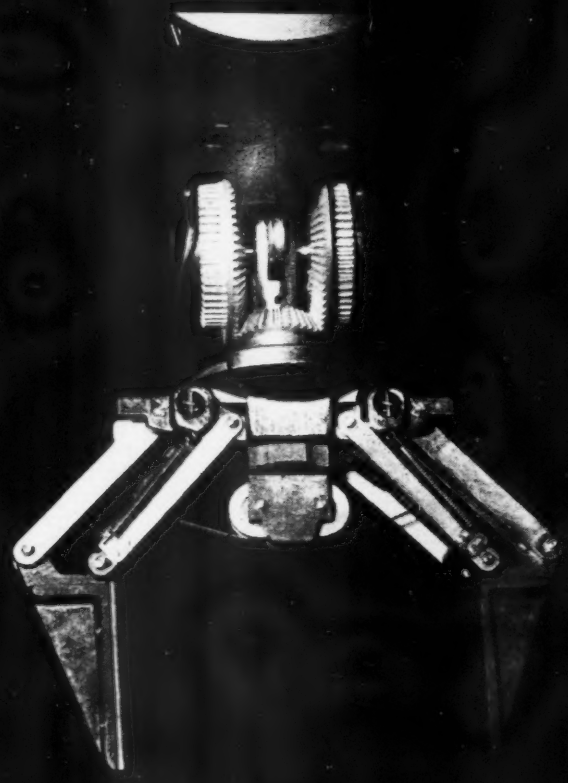
Two conferences reported

Australian Atomic Energy Symposium 1958 Melbourne University Press, 1959 788 pp

This is the complete proceedings of the miniature Geneva conference held in Sydney in June, 1958, and briefly reported in NUCLEAR POWER, August. Under the general chairmanship of Prof. J. P. Baxter, 144 papers were presented in five sections: materials, power engineering, power auxiliaries and research reactors, basic sciences, and associated techniques. The lively discussions held at the end of each section are included.

Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy. Her Majesty's Stationery Office, 1958
Vol. 8: Nuclear power plants, Part 1 548 pp £5
Vol. 17: Processing irradiated fuels and radioactive materials 709 pp £7 9s
Vol. 19: The use of isotopes: industrial use 366 pp £4 9s

Three more invaluable volumes of Geneva proceedings are now out, these with special interest for industry. Volume 8, which contains only half of the papers on nuclear power plants—the rest are to follow in volume 9—covers operating experience, plans for nuclear plant construction, and uses for nuclear energy other than electricity generation. Only the industrial use of isotopes is covered in volume 19—research applications are to come in volume 20.



Manipulators

The manipulators used at atomic establishments have to operate under exacting conditions. They are constructed of stainless steel and Kanigen plated aluminium and the plate serves two functions. It resists corrosion and, because of the smoothness of the finish, it also assists in decontamination of the component parts from radio-active material; and the combination of stainless steel and Kanigen plated aluminium reduces the electro potential difference between the component parts. These manipulators, manufactured by Savage & Parsons Ltd., are supplied to users all over the world. Kanigen is used on the aluminium parts of the Tong End assembly and the Ma ·er Hand assembly.

Kanigen

A HARD & CORROSION RESISTANT PLATE

KANIGEN is a nickel-phosphorus plate deposited by chemical reduction: thickness can be controlled to fine limits and is of complete and uniform coverage.

PROPERTIES:	
Composition	92% Nickel 8% Phosphorus
Melting point	890°C.
Electrical resistivity	60 microohm cm.
Hardness	500—1,000 V.P.N. according to heat treatment
Coverage	Extremely uniform

Kanigen can be applied to all ferrous metals, aluminium, copper and brass. The plating plant at Oldbury has now been extended, two extra plating tanks are in operation and enquiries for jobbing plating are welcomed. Full information is available on request.

Albright & Wilson
(MFG) LTD
Kanigen Department
I KNIGHTSBRIDGE GREEN · LONDON SWI

Kanigen is a regd. trademark of Albright & Wilson Ltd

TSW/931

KANIGEN

Tick **No 70** on reply card

Tick **No 71** on reply card for further details

Stockholders of STAINLESS STEEL

SHEETS · BARS · TUBES
STRIPS & BLANKS

PROFILE CUTTINGS &
SHEET POLISHINGS

COX AND DANKS
LIMITED

PROFILE CUTTING
TO ANY SHAPE

SCAPA HOUSE · PARK ROYAL RD.
LONDON N.W.10

Tel: Elgar 5811 Telex 25239

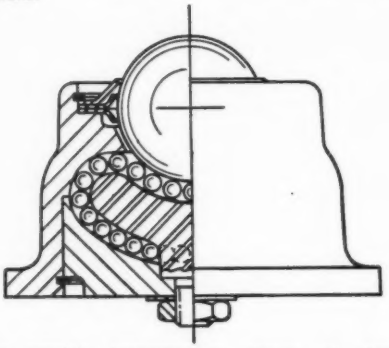
Tick **No 72** on reply card for further details

Make Light of Weight
with
AUTOSET

O.T.'s

World Patents Pending.

Omni-track Conveyor Ball Units having dynamic load capacities from 50 lb. to 5 tons each with ½" to 2" dia. load balls.



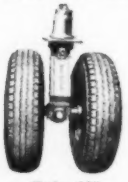
O.T.'s provide instantaneous change of direction automatically accommodated at any angle, with effortless ease. On cast iron or hardened steel plate starting effort may be as low as 1% with gross load. Special rotary applications as low as 0·25% per gross load.

Ask for List No. 275

CASTORS

Ask for List No. 275C

Over 25,000 types and sizes including wheels from 2" to 46" dia. and loads up to 30 tons each. Sprung, automatically braked, Ackerman steered, Jacked, direction or wheel-locking, etc.



Twin 46" Pneumatics, 6-ton

6" tubular shank, 90-lb.

Twin 20" solid tyred, 5-ton

DRAWER SLIDES

Ask for List No. 275S

Three-piece Extension Drawer Slides, 12" to 37" lengths

Two-piece Extension Drawer Slides, 10" to 25" lengths

Also Trolleys, Trucks, Conveyor Rollers, etc., etc.

AUTOSET (PRODUCTION) LTD.
73-78 STOUR STREET, BIRMINGHAM 18
Telephone : EDGBASTON 1143

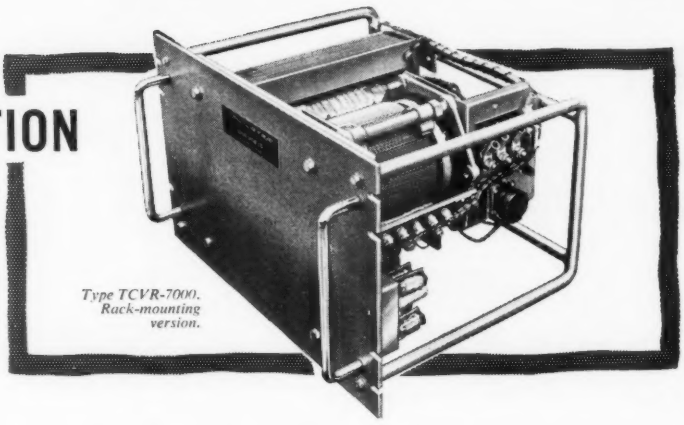
40 VOLTS/SEC AUTOMATIC CORRECTION

—with the type TCVR voltage regulator

The TCVR is a servomechanical automatic voltage regulator having the very high speed of correction of FORTY VOLTS PER SECOND. It provides an *undistorted* output, maintained constant within very close limits (normally ±0.5%) from no-load to full-load, for wide variations in frequency and power factor.

A wide range of models from 1.6 to 12 kVA single-phase, and 4.8 to 36 kVA three-phase. is available, to standard or tropical specification, in cabinets or for rack-mounting. Models are also available in which the output voltage is continuously adjustable over a wide range by means of a panel control. Regulators can be supplied to Services' specification, and special models can be designed to order.

For high-speed, accurate stabilisation *without distortion*—**specify TCVR.**



Type TCVR-7000, Rack-mounting version.

Other products of Claude Lyons Ltd. Stabiliser Division

BMVR: Motor-driven laboratory and industrial regulators ranging from 1·6 to 29 kVA single-phase, and 4·8 to 87 kVA three-phase. Constancy of output normally ± 0·5% from no-load to full-load. No distortion. Speed of correction 1 Volt/Sec. A great variety of models, standard, tropical and militarised, for all applications.

BAVR: Electronic stabilisers of very high accuracy, and very rapid response, with no moving parts. Input range : − 10% to + 5%, output constancy ± 0.15%. Three sizes : 200, 500 & 1000 VA. Exceptionally useful for control of chemical processes, heating, lighting, etc.

ASR: Automatic step regulators, small, inexpensive, and with sinusoidal output waveform. Two sizes : 1·15 kVA and 2·3 kVA. Input range − 10% to + 5%; output constancy, ± 2½%.

ATC: Automatic Tap-Changing Transformers — a development of ASR. Two sizes : 575 VA and 1150 VA. Input range − 20% to + 10% : output constancy, ± 5%. Provide adequate stabilisation for many types of apparatus, at low cost. Also useful as pre-regulators, e.g. in conjunction with BAVR.

We shall be pleased to send you full details of our entire range.

Claude Lyons Ltd.

Stabiliser Division **VALLEY WORKS · HODDESDON · HERTS · TELEPHONE HODdesdon 4541-4**

CL/47/E2B

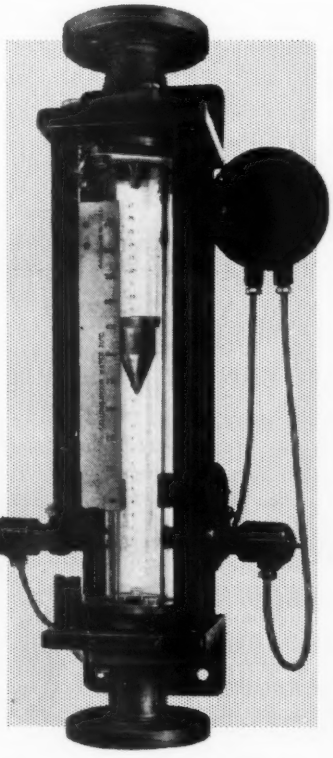
A photo-electric alarm is now available for fitting to Rotameter Flowmeters types 907 and 914. This unit is made in one size only which can be fitted to any size of instrument.

Note these advantages:

★ A positive signal to any remote instrument.
★ Can operate either a simple alarm or a digital counting mechanism.
★ Will signal high or low degrees of flow rate.
★ 2 alarms can be used to provide high and low flow alarm.

Keep an on flow

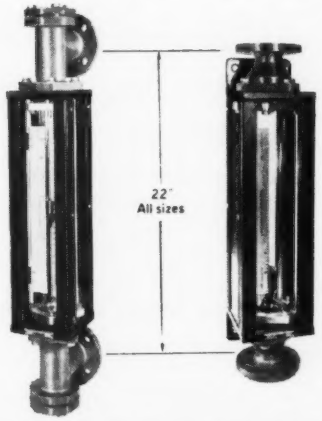
★ One size of alarm fits any size of type 907 or 914 frame.
★ Can be fitted to instruments already installed.



METRIC SERIES 'B' FLOWMETERS

The Metric series Rotameters employ standardised tubes and floats with three types of float (for different fluids) for e ch of eight sizes of tube. Tubes, floats and gland packing (including P.T.F.E.) of a given size are fully interchangeable.

Range : 0.1 to 200 L/min. Water at 20°C.
1 to 2000 L/min. Air at N.T.P.



ROTAMETER

FLUID MEASUREMENT AND CONTROL
FLOW-DENSITY-LEVEL

Write for technical details quoting reference NP/MA.

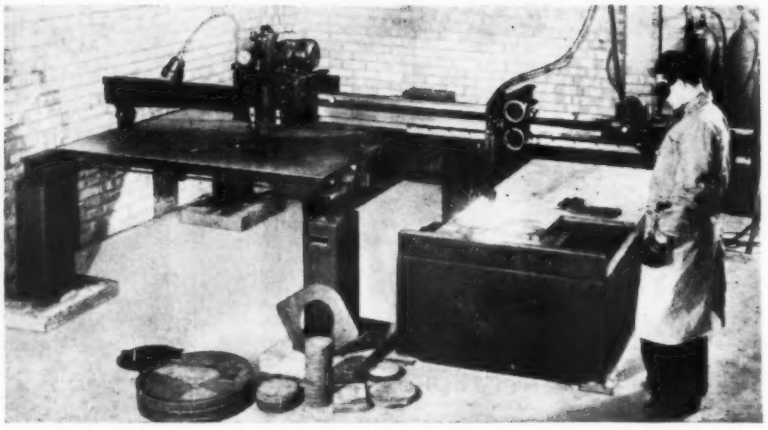
ROTAMETER MANUFACTURING CO. LTD., 330 PURLEY WAY, CROYDON **Tel : CROydon 3816**

Tick **No 75** on reply card for further details

TAYLOR

stainless steel plate profiling

makes life easier!



Write, call or phone. Our Area Manager will be pleased to call and discuss your needs.

Immediate capacity.
Any shape, size or thickness.
We work directly from your drawings.
No templates needed.
Latest patented cutting process.
Cut face needs no machining before welding.
Quick, reliable service.
Large plate stocks always available at MILL prices, or your own stainless steel cut.

TAYLORS ALSO PROVIDE SERVICE IN

Bar blank sawing up to 14" in dia.
Bar grinding from ¼" to 2" dia.
Sheet polishing 10—24 swg. up to 10' x 4'
Tube polishing from ¼" to 2¼" dia.

Ask for your copy of the TAYLOR STAINLESS STEEL priced stock list— new every 60 days.

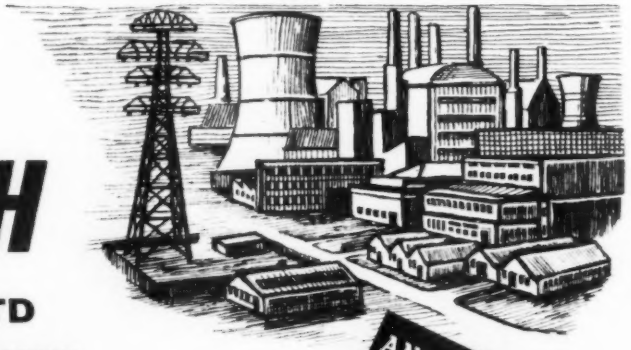
TAYLOR STAINLESS METALS LTD. A.I.D./A.R.B. approved

Buckingham Avenue · Slough · Bucks. Tel: Slough 23951 Midland Sales Office: 63 Temple Row, Birmingham 2. Tel: Midland 1430/4610

BRITAIN'S PRINCIPAL STAINLESS STEEL STOCKHOLDERS

WPS-21

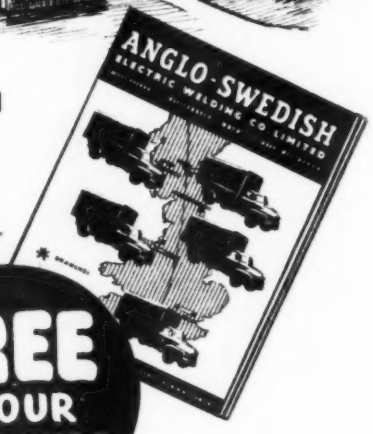
ANGLO-SWEDISH



ELECTRIC WELDING CO. LTD

FOR FIRST CLASS WELDING UNDER THE STRICTEST SUPERVISION

We have ample facilities for handling top-grade welding repairs to boilers, castings, machine parts, etc.—with expert technicians for Fabrication work, Structural Steel work, Tank construction and Electric Stud Welding. Let us send you this descriptive colour brochure.



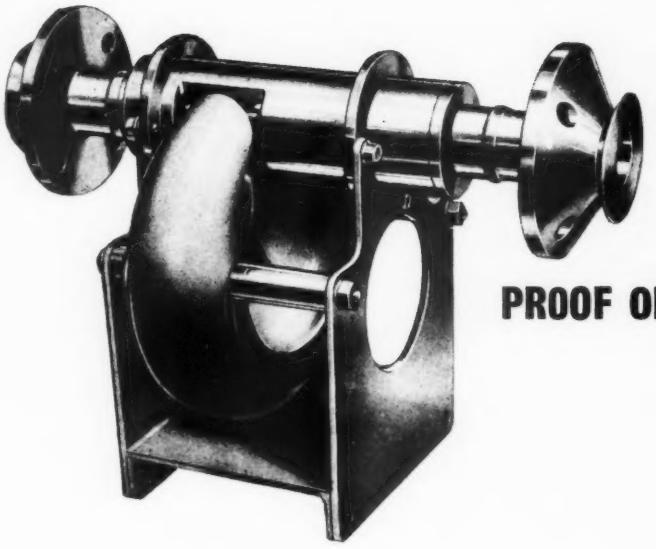
For immediate service contact us NOW—

ANGLO-SWEDISH ELECTRIC WELDING CO LTD
WOOD WHARF · GREENWICH · LONDON SE 10
Telephone: GREENWICH 2024-5

NEWCASTLE · LIVERPOOL
GLASGOW · LEITH · LONDON

FREE COLOUR BROCHURE

Tick **No 77** on reply card for further details



1" Liquid metal electro-magnetic flowmeters

PROOF OF PALATINE PRECISION . . . 2

Produced in our Surbiton factory, this flowmeter is designed to record accurate readings in conditions of varying temperature, flow, and turbulence without complications or bore restrictions.

Applicable to many liquid metal circuits, this 1" normal bore flowmeter gives consistently accurate results.

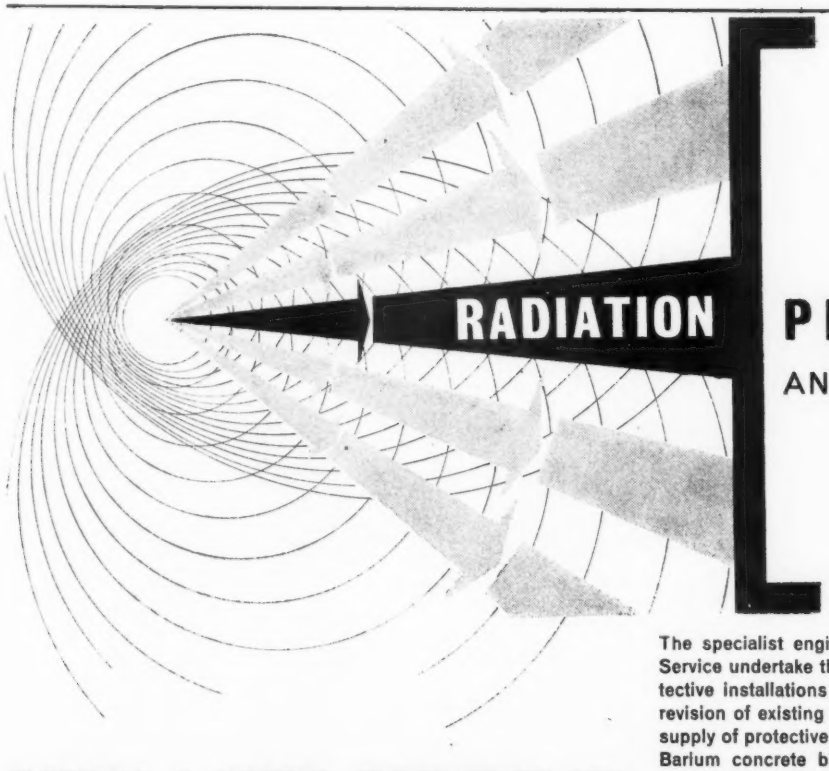
Perhaps this experience and technical ability could be of value to your Organisation. The development and production of prototypes of such equipment is Palatine's particular province.

PALATINE

Write or telephone

PALATINE TOOL & ENGINEERING CO. (SURBITON) LTD.

64-76 Brighton Road, Surbiton, Surrey Telephone: Elmbridge 7261-3



PROTECTION

AN ADVISORY SERVICE

The specialist engineers of **R.C.I.'s Radiation Protection** Service undertake the design and construction of new protective installations for both **Gamma and X-rays, and the** revision of existing protective measures, in addition to the supply of protective materials.

Barium concrete blocks · Lead ply panels · Lead lined sliding doors · Lead glass windows · Mobile screens for open site work · Lead containers for isotope storage.

X-ray equipment and protection for all industries.

(RCI 0400)

RESEARCH & CONTROL INSTRUMENTS LTD.

Instrument House, 207 King's Cross Road, London, W.C.1

Tick **No 78** on reply card for further details

Tick **No 79** on reply card for further details

'HYDROBORD'

for

NEUTRON SHIELDING

HYDROBORD provides insulation against Fast and Thermal Neutrons or combinations of both.

William Mallinson and Sons Ltd.

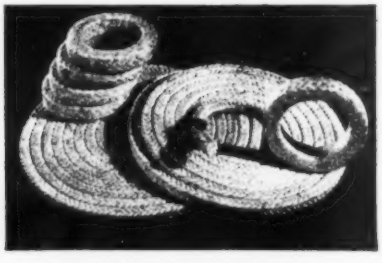
130 HACKNEY ROAD · LONDON · E.2

Telephone: Shoreditch 7654 Telegrams: 'Almoner', London

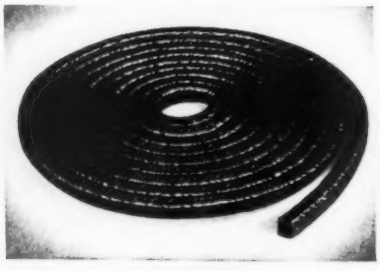
Lydney WATER and BOIL PROOF BRITISH MADE PLYWOOD

LASCAR PACKINGS for INDUSTRY

The widely varying needs of Industrial Engineering are fully met from the range of LASCAR Packings. From water and steam to highly corrosive acids, tough, resilient, durable, LASCAR Packings meet all existing requirements and most new ones.



WHITE BELDAMOK
The specially developed graphite-free packing for superheated steam at temperatures up to 1100°F.



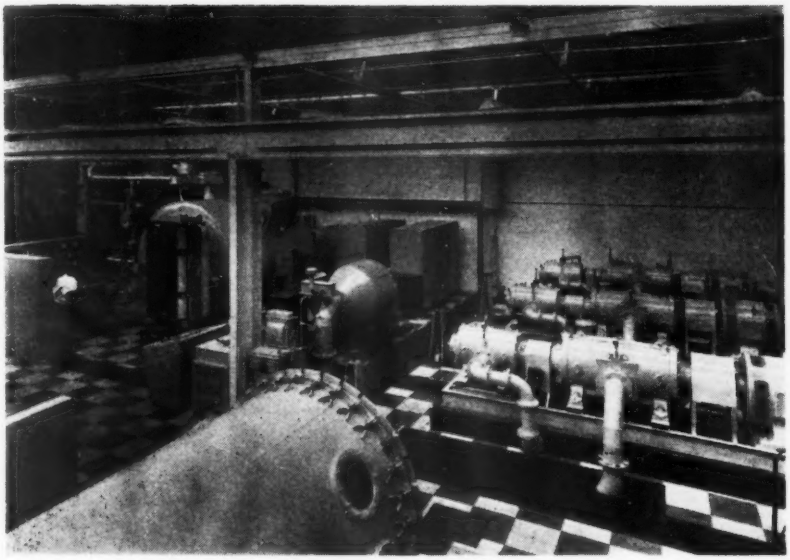
BELDAMOK
The high grade asbestos packing lubricated for general high-temperature service up to 650°F.

BEDFORD
A range of metal foil packings combining low friction with good resilience and designed for high speed rotating shafts.

Telephone or write for your copy of the LASCAR Manual—the best guide to better service in the application of jointings and packings.

BELDAM'S

LASCAR PRECISION PACKINGS
BELDAM ASBESTOS COMPANY LIMITED · LASCAR WORKS
HOUNSLOW · MIDDLESEX · Telephone: HOUnslow 7722 (10 lines)



Part of the English Electric Aircraft Equipment Laboratories with three HOLLAND/SLM 2-stage rotary vacuum pumps exhausting the altitude test chamber.

HOLLAND / SLM

ROTARY COMPRESSORS AND VACUUM PUMPS

GIVE SERVICE FOR TO-DAY FOR TO-MORROW AND FOR YEARS AHEAD

The B. A. Holland Engineering Co. Ltd.

LINDO LODGE, STANLEY AVENUE, CHESHAM, BUCKS.

Telephone: Chesham 8406/8 Telegrams: Picturable, Chesham Works: SLOUGH, BUCKS

Man and Method

The result of this craftsman's work will be an interior surface, smooth as silk—without blemish, and completely safe for the bulk transportation of edible liquids.
He is skilled and proud of it and, like his colleagues in other crafts, he meets the exacting demand set by Darham in the construction of road tanks, transportable tanks and storage tanks for customers in countless industries at home and overseas.

DARHAM TECHNICAL ADVISORY SERVICE is on call to you. If you would have tanks that are accepted as a standard by which others are judged you will seek the advice of Darham.

DARHAM build fine tanks in Mild Steel (suitably lined if necessary), Stainless Steel and Aluminium.

Darham

DARHAM INDUSTRIES (LONDON) LIMITED
17 Surrey Street, Strand, London, W.C.2.
COVent Garden 0556
WORKS: BASILDON ESSEX AND DURHAM CITY

JOHN THOMPSON GROUP

Tick **No 83** on reply card for further details

W&J OIL FREE COMPRESSORS

DISPLACEMENT RANGE 1 to 136 c.f.m.

In the Food Processing, Brewing, Chemical and Paper Industries, also for pneumatic instrument control, it is essential that the air is free from oil in both droplet or vapour form. The W&J compressors use carbon rings and completely dry cylinders to achieve this purpose.

Manufactured now for several years they have proved themselves successful in many industries.

For further details please write requesting Leaflet Nos. 4, 20, and 28.

Illustrated is the twin cylinder model having a free air delivery of 50 c.f.m.

WILLIAMS & JAMES (ENGINEERS) LIMITED
GLOUCESTER · ENGLAND
TELEPHONE: GLOUCESTER 24021-2-3 · TELEGRAMS & CABLES: "COMPRESSOR GLOUCESTER"

MILNE for welding & cutting equipment

All Milne equipment is designed by practical engineers who know the exact requirements of the Welding and Allied Industries. It includes Brazing, Welding and Cutting Blowpipes, Regulators to suit every purpose, Cutting and Profiling Machines, Gas Economisers, Valves for Pipe Lines and other necessary welding accessories.

To provide a comprehensive welding service Milne also offer Electric Arc and Resistance Welding Plant and Equipment.

For full information and details write to:-

C. S. MILNE & CO. LTD.

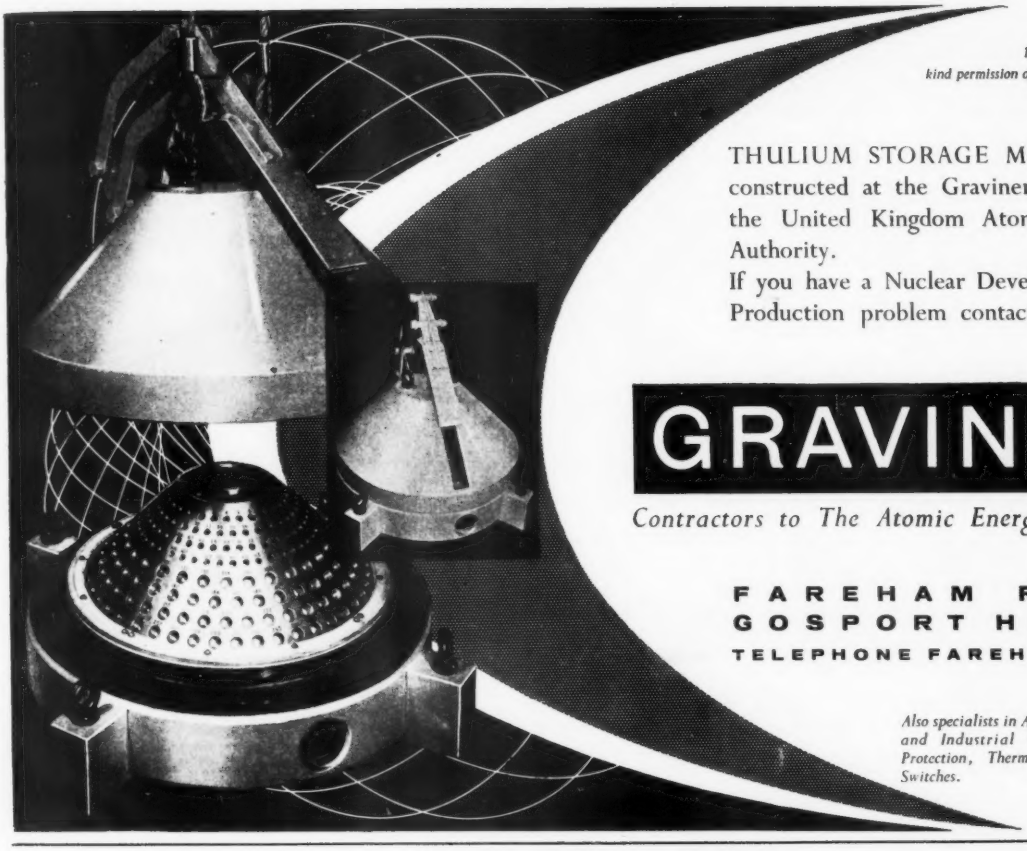
Manufacturers of Gas Welding and Cutting Plant and Equipment
Stockists and Suppliers of Electric Arc Resistance Welding Equipment

Harley Works, Octavius St., Deptford, London, S.E.8

Telephone: Tideway 3852

Also at 172/174 West Regent Street, Glasgow, C.2

TIB 112



Photographs by kind permission of U.K.A.E.A.

THULIUM STORAGE MAGAZINE constructed at the Graviner works for the United Kingdom Atomic Energy Authority.
If you have a Nuclear Development or Production problem contact us today.

GRAVINER

Contractors to The Atomic Energy Authority

FAREHAM ROAD
GOSPORT HANTS
TELEPHONE FAREHAM 2511

Also specialists in Airborne, Diesel Engine and Industrial Fire and Explosion Protection, Thermostats and Overheat Switches.

You can rely on Gem

THE BEST WIRE BRUSH IN THE WORLD

TRADE MARK

See them at your local tool wholesaler or write to

GEM POWER BRUSHES LTD., EST. 1874

GEM WORKS (DEPT. 9), MINERVA ROAD, LONDON, N.W.10. Tel.: ELGar 7251 (5 lines)

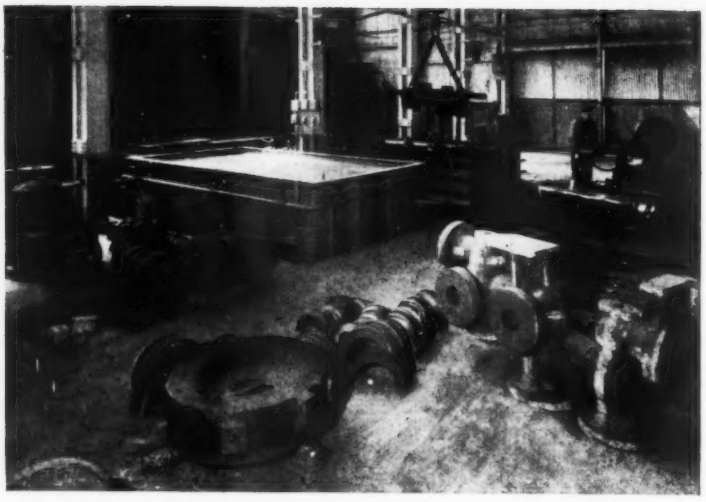
ROTARY POLISHING & LATHE BRUSH DIVISION, KINGSWOOD MANUFACTURING CO., LTD.

Tick **No 87** on reply card for further details

ATLAS

STEEL CASTINGS

For Internal Pressure Work



Turbine Castings, Steam Chests, Valves, etc. in carbon and alloy steels up to 9 tons weight and to any specification.

ON ADMIRALTY, WAR OFFICE, LLOYD'S and other LISTS

THE ATLAS STEEL FOUNDRY & ENGINEERING COMPANY, LIMITED

ATLAS STEEL WORKS: ARMADALE, WEST LOTHIAN, SCOTLAND

Telegrams: "ATLAS ARMADALE WEST LOTHIAN" Telephone No.: Armadale 323

This is *one* of your problems...

... solved

... where to find an engineering organisation with the requisite amount of skill, experience, facilities and aptitude for accuracy, may be your problem today or tomorrow. Cornercroft is just such an organisation ... fully equipped to produce high-precision assemblies, jigs, tools, handling equipment, cabinets, ducts, sheet metal work, metal spinnings, pressings, plastic mouldings, prototypes, experimental rigs etc. ... and we have the experience and an established reputation for unusually fine workmanship. We can probably help you ... may we discuss your needs?

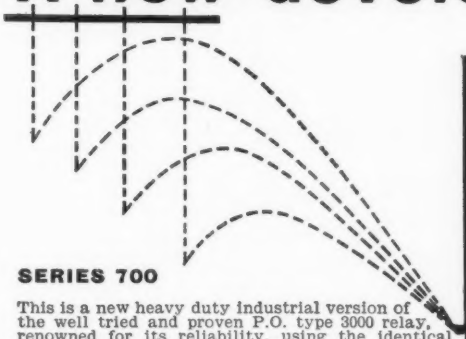
CORNERCROFT
precision engineering service

CORNERCROFT LIMITED
(The Cornercroft Group of Companies)
Ace Works, Coventry.
Telephone Coventry 40561.

NC.271

Tick **No 89** on reply card for further details

A *new* development in relays

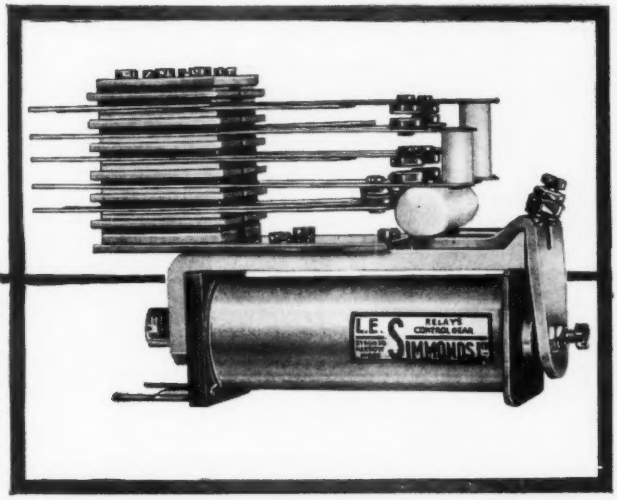


SERIES 700

This is a new heavy duty industrial version of the well tried and proven P.O. type 3000 relay, renowned for its reliability, using the identical magnetic circuit as the type 3000 but offering up to **8 sets of contacts** of either makes, breaks or changeovers **at 250v A.C. up to 15 amps.**

All moving insulators are of P.T.F.E. Contact pressures have been increased in order to withstand severe shock and vibration conditions as encountered in many industrial applications. Coils wound **from ¼Ω to 100,000Ω** and slugged if required. **Flash test 2,500 volts** between contacts coil and frame. Various contact materials to specification—full tropical finish. A rugged relay designed for faultless operation and long life far in excess of its type 3000 predecessor.

Prototypes within 24 hours. *Quantity deliveries commencing 14-21 days.* **NOW IN PRODUCTION.**



POST OFFICE TYPES
Manufacturers of P.O. types 3000 and 600 relays to specification. Approved by the Admiralty, Post Office and U.K.A.E.A. All relays guaranteed made in our own works.

SIMMONDS

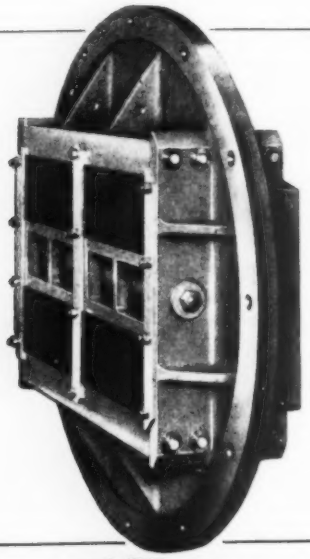
Manufacturers to H.M. Government Departments and leading Contractors

L. E. SIMMONDS LTD., 5 BYRON ROAD, HARROW, MIDDX. TEL: HARROW 7797/9. TELEGRAMS: SIMRELAY HARROW

BARYTES
SHIELDING
PRODUCTS
X RAY
COBALT
A
FEBASO
BARYTES SHIELDING PRODUCTS LTD
BLOCKS · BRICKS · TILES · SPECIALISED · AGGREGATES
61-62 CRUTCHED FRIARS, LONDON, E.C.3
TELEGRAPHIC ADDRESS: BARIWALL · FEN · LONDON TELEPHONE: ROYAL 2436
DENSE SPECIALISED AGGREGATES READY MIXED 220-300 per cube foot
DENSE CONCRETE MIXTURES READY MIXED ADD WATER ONLY

Tick **No 90** on reply card for further details

Tick **No 91** on reply card for further details



AMAL

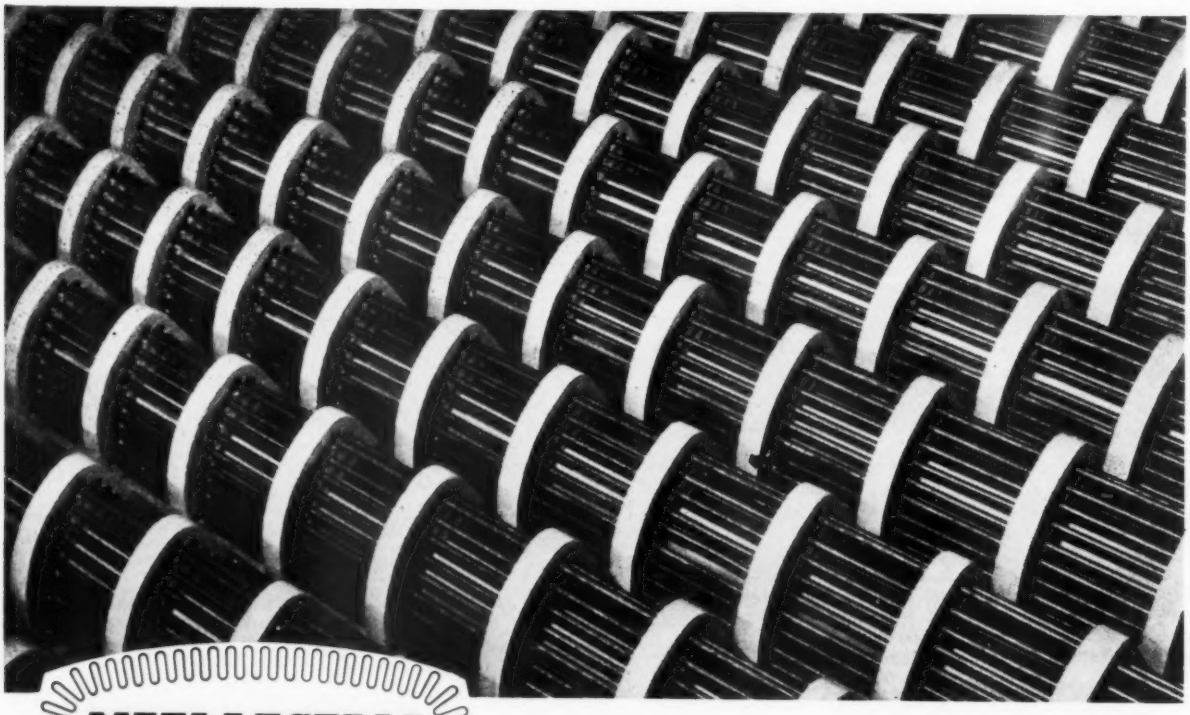
A Special Unit constructed by us for the U.K.A.E.A.

We have had extensive experience in the manufacture of many engineering products such as

FLOWMETERS · FUEL PUMPS
JET CALIBRATING MACHINES
FUEL FILTERS · FLAP VALVES
FLAME TRAPS · GAS INJECTORS
FUEL PRESSURE REGULATORS

Now added to this List is Equipment for the U.K.A.E.A.

Enquiries to:
Amal Ltd · Witton · Birmingham · Phone Birchfield 4571 (6 lines)
A210



METALECTRIC

our custom-built radiant and immersion elements can solve your nuclear engineering thermal problem.

METALECTRIC FURNACES LTD · SMETHWICK · ENGLAND
11/25/58

MEL MAGNOX *and then?*

The recognised authorities on every aspect of magnesium technology, MEL are constantly evolving new alloys and improving existing ones.

Magnox you know about. MEL are approved suppliers of this important canning material for the UKAEA. In collaboration with UKAEA and the industrial consortia they are contributing their considerable research acumen to the further development of magnesium alloys, specifically designed for nuclear work.

The skill and experience of MEL are available to all who wish to exploit the special advantages of the latest magnesium alloys in nuclear engineering projects.

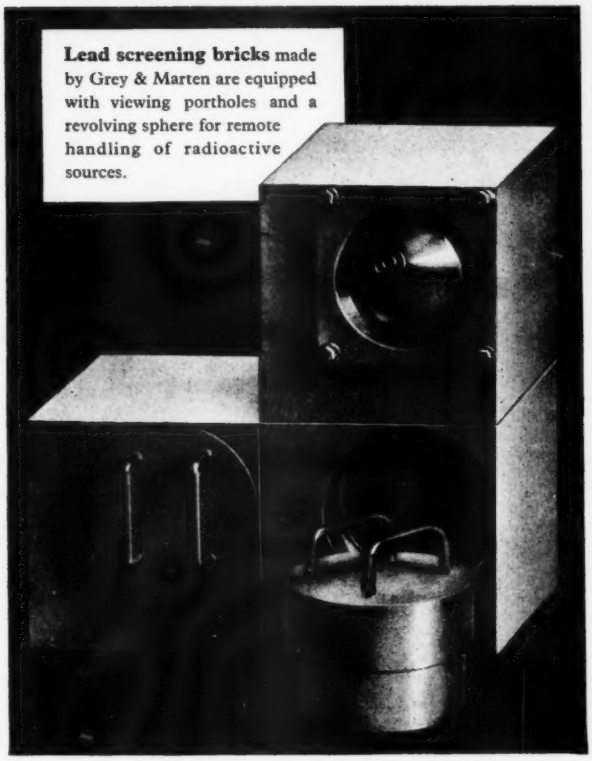
MEL

MAGNESIUM ELEKTRON LTD

Clifton Junction Manchester
Swinton 2511

London Office: 5 Charles II Street St. James's SW1
Trafalgar 1646

Magnesium Elektron, Inc., New York 20, USA

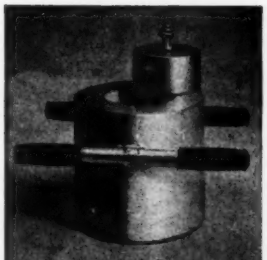


Lead screening bricks made by Grey & Marten are equipped with viewing portholes and a revolving sphere for remote handling of radioactive sources.

Ask Grey & Marten about lead shielding

(Their new subsidiary, James Girdler & Co., has all their skill and experience)

GREY & MARTEN are experts in lead. They've specialised in the manufacture of *all* kinds of lead castings, fabrications and fillings for more than a century. Interlocking Lead Bricks (in one, two and four-inch thicknesses), Lead Sphere Units (in two and four-inch bricks), Aperture and Viewing Bricks, Lead Pots and Isotope Carriers are all produced under the Grey & Marten name. Now they have handed over this activity to their new subsidiary, James Girdler & Co. Ltd.



Storage pot typical of those used in standard safes not already fitted with lead protection, affords economical storage for radio-active material.

GREY & MARTEN LTD

Established 1833

CITY LEAD WORKS, SOUTHWARK BRIDGE, S.E.1
and at Birmingham, Manchester and Ipswich

JAMES GIRDLER & CO. LTD

Mansell Works, Mansell Road, London W.3 CHISWICK 5991

Photograph by courtesy of United Kingdom Atomic Energy Authority

Ore Store, purification and blending buildings at Springfield Uranium Plant, Lancashire

THE TEES SIDE BRIDGE & ENGINEERING WORKS LTD.
MIDDLESBROUGH *London Office:* 56 Victoria Street, S.W.1

"Tees Side"

CRYSTAL PHOSPHORS

Hilger & Watts crystal phosphors are highly efficient in detecting and resolving X-rays and gamma-rays, and so are well suited for use in pulse-height analysers. We grow them from very pure melts of thallium-activated sodium iodide, and their potassium content is negligible.

We make a standard range of crystals, whose sizes range from ½ in. in diameter and ½ in. thick, to 4½ in. in diameter and 2 in. thick. The crystals are mounted in metal containers, which are lined with magnesium to increase their light output.

HILGER & WATTS

HILGER & WATTS LIMITED 98 ST PANCRAS WAY LONDON NW1 *Tel: GULliver 5636*

ce-
om

ls,

ys-
rs,

59

SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER.

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER.

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER.

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на карточке на противоположной стороне и отправьте в NUCLEAR POWER.

讀者詢問服務

在廣告上以有限的地方來解釋一些專門技術及它們的功能的確是有受限制的困難。若讀者欲要知道一些詳細的情形就請將對貴的表格取一張下來將閣下有疑問的項目問號勾一下寄給子能工程忌即可。

読者サービス

廣告紙面の関係上製品の技術的細目は掲載しきれません。もし詳しくは裏のカードの適当なナンバーに印をつけて原子力技術誌までお送りください。

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Tech. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE

Advertisements

1	24	47	70	93	116	139	162	185
2	25	48	71	94	117	140	163	186
3	26	49	72	95	118	141	164	187
4	27	50	73	96	119	142	165	188
5	28	51	74	97	120	143	166	189
6	29	52	75	98	121	144	167	190
7	30	53	76	99	122	145	168	191
8	31	54	77	100	123	146	169	192
9	32	55	78	101	124	147	170	193
10	33	56	79	102	125	148	171	194
11	34	57	80	103	126	149	172	195
12	35	58	81	104	127	150	173	196
13	36	59	82	105	128	151	174	197
14	37	60	83	106	129	152	175	198
15	38	61	84	107	130	153	176	199
16	39	62	85	108	131	154	177	200
17	40	63	86	109	132	155	178	201
18	41	64	87	110	133	156	179	202
19	42	65	88	111	134	157	180	203
20	43	66	89	112	135	158	181	204
21	44	67	90	113	136	159	182	205
22	45	68	91	114	137	160	183	206
23	46	69	92	115	138	161	184	207

New Products and Tech. Literature

208	214	220	226	232	238	244	250	256
209	215	221	227	233	239	245	251	257
210	216	222	228	234	240	246	252	258
211	217	223	229	235	241	247	253	259
212	218	224	230	236	242	248	254	260
213	219	225	231	237	243	249	255	261

Books

262	264	266	268	270	272	274	276	278
263	265	267	269	271	273	275	277	279

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME

NAME OF BUSINESS

ADDRESS

POSITION HELD

NATURE OF BUSINESS

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

SUBSRCIPTION CARD

YES!

I want my own PERSONAL copy!

Please send me NUCLEAR POWER for 12 months/until countermanded:

U.K. **£2. 2s. 0d.**

U.S.A. and Canada **$8.00 + 50c.** postage

Other countries **£3. 3s. 0d.**

starting with the _____ issue

☐ Subscription enclosed

☐ Invoice me later

NAME _____

SEND TO MY HOME/BUSINESS ADDRESS _____

Postage will be paid by uclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by uclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by uclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Tick No 97 on reply card for further details

MEN OF MILLIONTHS

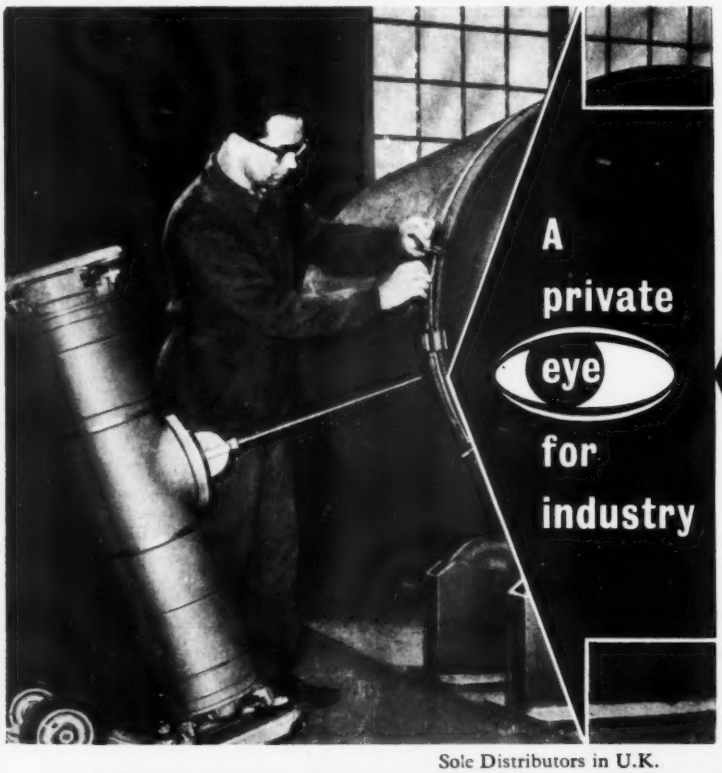
The new problems of precision engineering born of nuclear research—the intractable metals, the unusual shapes, the exacting accuracy—are no novelty to us at Armstrong Whitworth. We have been solving these for years in aircraft and missile manufacture, and one result of this is the unparalleled array of precision machine tools that you will find in our temperature controlled, dust-free machine shop. Highly competitive costs have also been made possible by new techniques we have evolved, and all these benefits will be gladly shared with you. May we solve your problem?

FOR PRECISION MACHINING CONTACT:—

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD

Baginton, Coventry. Telephone: Toll Bar 2261

A MEMBER OF THE HAWKER SIDDELEY GROUP



Ruggedly built, but still mobile, the Muller Macrotank H is specially developed for on-site radiographic examination in heavy industry, ship and bridge building, nuclear power and refinery construction — wherever complete and accurate weld examination is essential. The small focus (2.3 mm.) of the Macrotank H gives really sharp definition, with a penetration of up to 2½" of steel with Pb screens in reasonable exposure time. It is low in cost, reliable in use, and backed by full service facilities which may be on contract if desired. We shall be glad to send you full details.

The Macrotank H is a product of C. H. F. Muller, Hamburg.

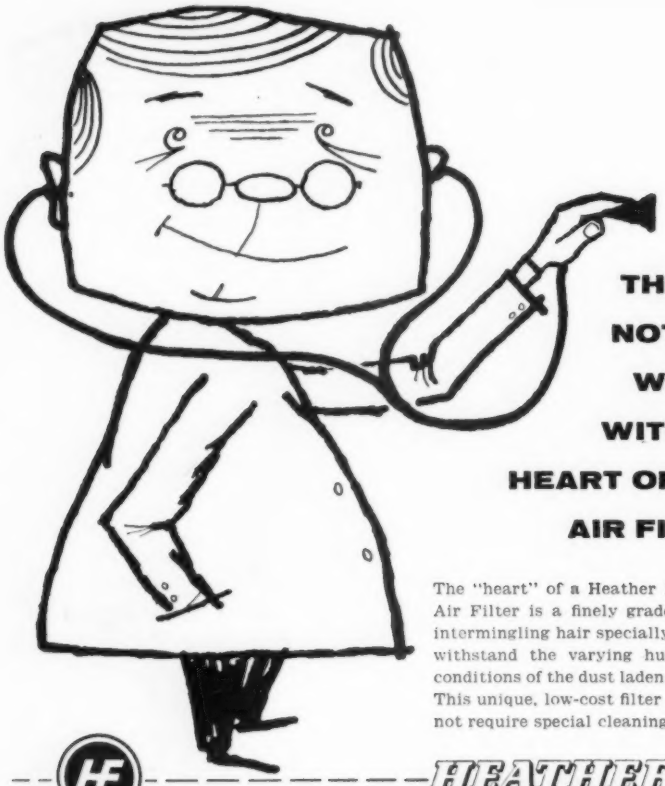
Sole Distributors in U.K.

RESEARCH AND CONTROL INSTRUMENTS LIMITED

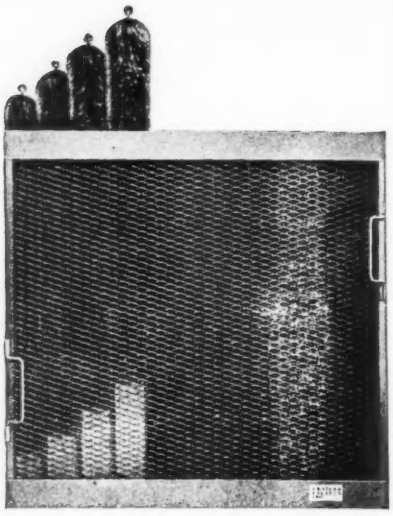
Instrument House, 207, King's Cross Road, London, W.C.1. TERminus 8444

(RCL0476A)

Tick No 98 on reply card for further details



THERE'S NOTHING WRONG WITH THE HEART OF THIS AIR FILTER!



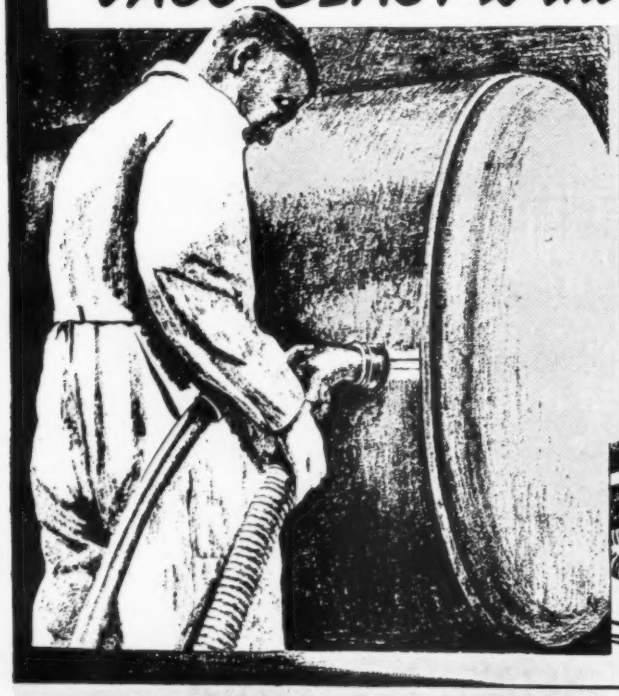
The "heart" of a Heather Multi-Brush Air Filter is a finely graded screen of intermingling hair specially selected to withstand the varying humidity, and conditions of the dust laden air.
This unique, low-cost filter system does not require special cleaning equipment, fluids, replacement pads or fabrics — simply remove the filter brushes and free them from dust by shaking or suction cleaning. Heather Multi-Brush Air Filters may be built-up into units to provide the area necessary for any given air flow.

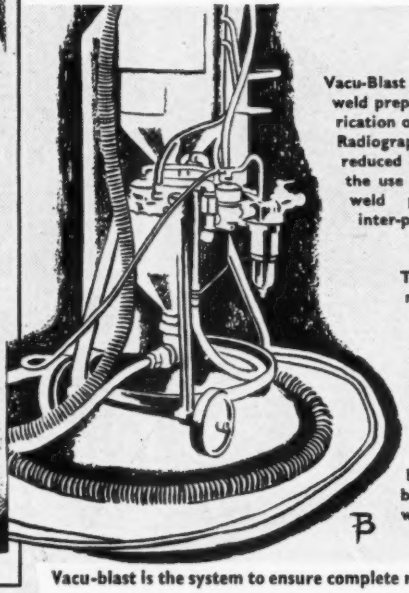
* *Write NOW for brochure H38 which gives full details.*

HEATHER FILTERS LIMITED

28 ST JAMES'S PLACE · LONDON · SW1 HYDE PARK 7588

VACU-BLAST is the pre-requisite of all good welding





Vacu-Blast is unequalled for weld preparation in the fabrication of pressure vessels. Radiographic rejects can be reduced considerably by the use of Vacu-Blast for weld preparation and inter-pass deslagging.

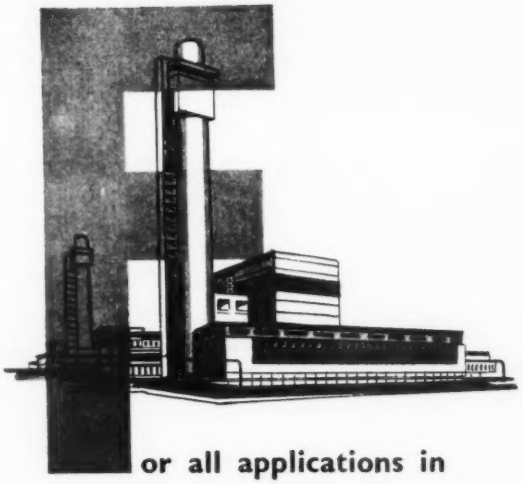
The critical requirements imposed by Class I welding specifications necessitate the use of this mobile, dust free, grit blasting process.

Demonstrations can be arranged at your works.

Vacu-blast is the system to ensure complete recovery of abrasive

VACU-BLAST LTD., BATH ROAD, SLOUGH, BUCKS. *Phone: SLOUGH 24507/9*

Tick **No 101** on reply card for further details



or all applications in Nuclear Power plants . . .

. . . continue to fit

FREMO STAINLESS STEEL

bolts, nuts, screws and other fasteners with corrosion, contamination and heat resistant properties.

FREMO
TRADE MARK

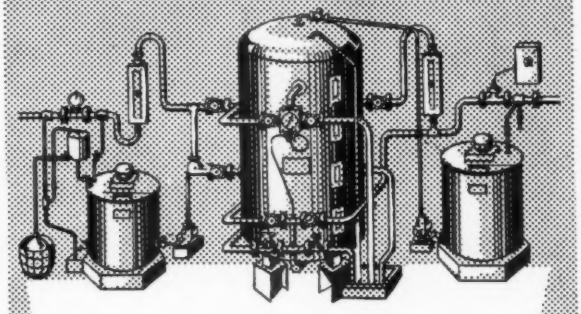
FREDERICK MOUNTFORD
(BIRMINGHAM) **LIMITED**

Fremo Works, Moseley St., Birmingham, 5
Tel. MIDland 7984 PBX
Grams 'FREMO' Birmingham

Tick **No 102** on reply card for further details

PURE WATER

for Industrial purposes



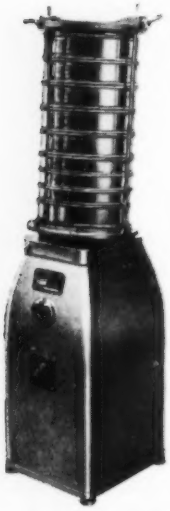
ION EXCHANGE

is the most up-to-date method of producing pure water for all requirements, and it does this at a fraction of the cost of distillation.

Literature, describing the full range of Ion Exchange processes and plants, available on application.

NECKAR

NECKAR WATER SOFTENER CO. LTD.
Artillery House · Artillery Row · London, S.W.1.



accurate particle size analysis

Simply vibrating or shaking test sieves by hand is not enough for an accurate sieve analysis of the particle size range of a material.

Vibration alone tends to aggregate rather than segregate particles, and shaking test sieves by hand is tedious and obviously inefficient.

The Inclyno Test Sieve Shaker, with a double movement that gyrates and jolts the test material around the entire surface area of the mesh of each test sieve, ensures perfect segregation of the various particle sizes in the shortest possible time.

The Inclyno Test Sieve Shaker is an essential unit for all laboratories and is standard equipment for sieve analyses in many government laboratories, nationalized industries and industry in general.

Operated by fractional h.p. motor and supplied complete with automatic time switch covering test periods up to 60 minutes. Three models available for all sizes of standard test sieves.

INCLYNO

TEST SIEVE SHAKER

Write or telephone Crawley 25166 for List IN 3206

THE PASCALL ENGINEERING CO LTD
GATWICK ROAD · CRAWLEY · SUSSEX

Established 1884

SOOLE

RADIATION PROTECTION

Lead Lined Doors and Frames, Screens and Panelling • Leaded Glass Window Units • Baryte Shielding • Complete Protection Schemes Undertaken to Specification

SOOLE & SON LIMITED
Dunstable Road · Richmond · Surrey
Telephone : **Richmond 0038**

LARK TUBE CLEANING EQUIPMENT

cuts breakdown costs!

LARK 'GD 250' TUBE CLEANER

for Condensers and Heat Exchangers

Powerful geared 'Lark' air motor speed 2.000 r.p.m. operating pressure 80 lbs./sq. in. designed for straight tubes ½" to 2" I.D. Drills, reamers, brushes supplied together with drive and driven shafts of any length. Replaces slow hand cleaning methods.

Please write for further details of Lark tube cleaning equipment.

INDUSTRIAL DESCALING TOOLS LTD
Sole distributors for the manufacturers H. WILLIAMS & SON LTD
LARK WORKS, SANDRIDGE ROAD, ST. ALBANS, HERTS.
Telephone St. Albans 56026 · Telegrams Descaltool, St. Albans

UKAEA
ENQUIRIES INVITED

S.M.P

PRECISION ENGINEERS

BRIEF PARTICULARS OF PLANT INSTALLED

LATHES : Capstan, Screw Cutting, Special Purpose.
MILLING MACHINES : Plain, Universal, Vertical, Special Purpose.
DRILLING MACHINES : Radial, Sensitive, Multi Spindle, Tapping.
GRINDING MACHINES : Plain, Universal, Surface, Internal.
BORING MACHINES : Single Spindle, Double Ended.
BROACHING MACHINES
AUTO SCREW MACHINES : Single Spindle up to 2¾" dia. Multi Spindle up to 2¼" dia.
PRESSES : Up to 100 ton.

Stove Enamelling, Assembly, Linishing, Roto Finish, Plating, and Hardening Shops, including H.F. Hardening

TOOLROOM, EXPERIMENTAL DEPARTMENT, AND OWN DESIGN AND DRAWING OFFICE.

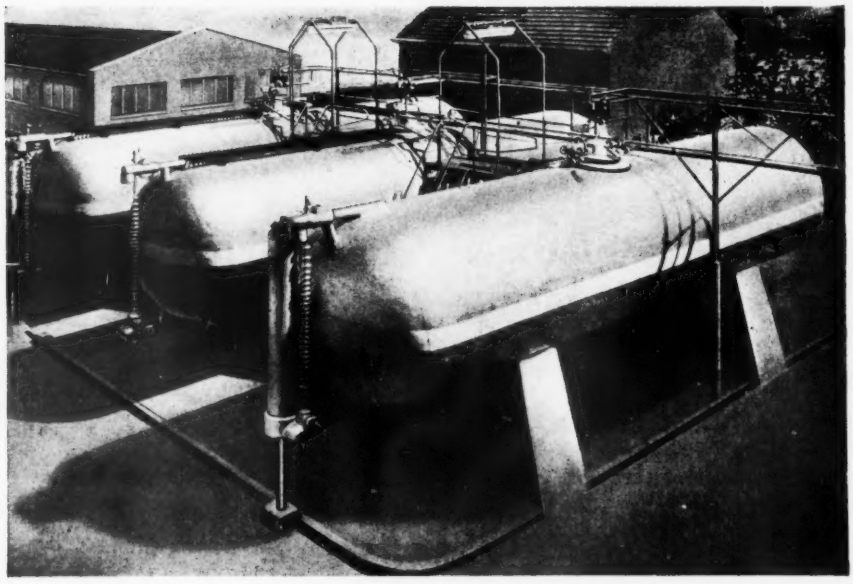
Approved A.I.D., D.I.Arm., A.R.B. and also Approved tenderers to the U.K.A.E.A.

★

We are machining specialists in stainless and various high tensile steels.

SCREW MACHINE PRODUCTS LTD.
Wooburn Green, Nr. High Wycombe, Bucks.
Telephone: Bourne End 111 & 101

CO_2



This illustration shows a storage installation for 150 tons of Liquid CO_2 at low pressure.

We supply complete installations including Vapourisers for large scale CO_2 discharge, automatic apparatus and control instruments.

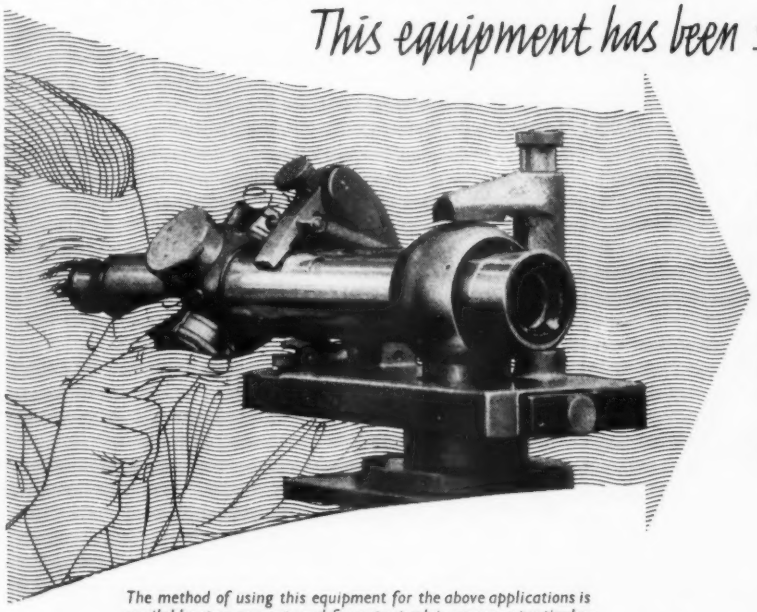
We also supply liquid and solid CO_2 production plants from a variety of fuels or from by-product gases with capacities of ½-ton per day upwards with guaranteed purity of the CO_2 produced.

LLOYD & ROSS LTD

58 Victoria Street, S.W.1.
Telephone: Victoria 4873
Cables: LOYDROS, LONDON
Maschinenfabrik ESSLINGEN, Germany.

'MICRO' ALIGNMENT TELESCOPE

This equipment has been successfully used by . . .



. . . the United Kingdom Atomic Engineering Research Establishment in the construction of Experimental Nuclear Reactors and the associated Projects ZETA, BEPO, ZEUS, ZEPHYR, DIDO and PLUTO. Also used by the leading manufacturing groups in the construction of Nuclear Power Stations, of the Power Supply Plan in Great Britain.

Sets and checks **ALIGNMENT PARALLELISM·SQUARENESS** *and generate* **PLANE SURFACES**

The method of using this equipment for the above applications is available upon request, and for expert advice on your particular problem, please apply to Optical Tooling Engineers' Dept.

TAYLOR-HOBSON

A Division of RANK PRECISION INDUSTRIES LTD.

TAYLOR, TAYLOR & HOBSON, LEICESTER, England.

AT 29

Tick **No 108** on reply card for further details

A.I.D. A.R.B.

WHAT ARE YOU LOOKING FOR?

CONTROL VALVES!

GAS BOXES!

HYDRAULIC MECHANISMS!

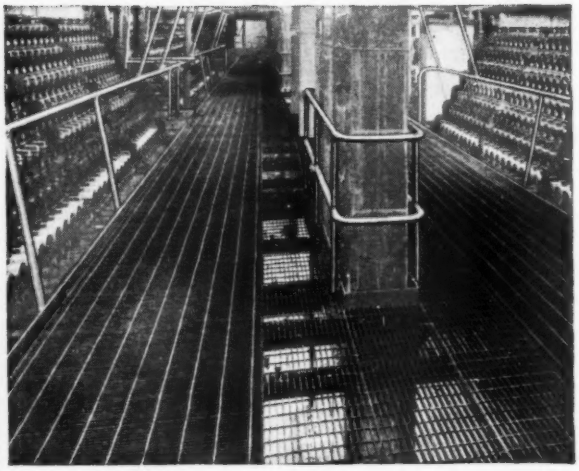
We cover all fields from small CONTROL VALVES to COMPLEX FABRICATION for HIGH VACUUM WORK to intricate HYDRAULIC MECHANISMS with delicate instrument like sub-assemblies.

Facilities exist for: Ideally clean assembly to U.K.A.E.A. requirements—deep freeze testing to —50°C also for design and development of equipment for your special needs.

SANDALL PRECISION CO. LTD.

WATLING STREET, BLETCHLEY, BUCKS

Tel: 3456-8 PBX *Grams: SANDALL BUCKS*



Non-Slip **MECHANICALLY LOCKED No. 3 Type**

OPEN STEEL FLOORING

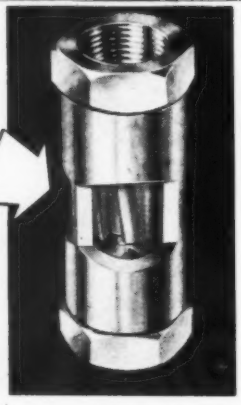
Ideal for factories, warehouses, refineries, gas works, fire escapes, etc.
Supplied with handrails and standards if desired.

by Bettles

Our technical staff will be pleased to assist you

BETTLES & SONS LTD., ARCWEL FACTORY
STAFFORD ROAD, FORDHOUSES, WOLVERHAMPTON
Telephone: Fordhouses 2278-9

See the flow with the 'Telicator'



Both low and high pressure systems can be fitted with a Telicator Visual Flow Indicator, which is a simple instrument for indicating the flow, whatever the viscosity. The rotors are specially designed by Dukes and Briggs to give the clearest indications over specific ranges of flow rate. Water supplies for cooling purposes and forced lubrication systems are two typical applications. A new model is under development for use with opaque fluids, and special designs can be made to meet specific requirements.

Note these features

- *Simple design ensures complete reliability.*
- *Extreme sensitivity at all pressures.*
- *Units readily adaptable to existing installations.*
- *May be mounted in any plane.*
- *Comparative flow gauged by speed of revolving rotor.*

Bailey's REGD.

SIR W. H. BAILEY & COMPANY · LIMITED
PATRICROFT · MANCHESTER · ENGLAND
Phone: Eccles 3487-8-9 Grams: Beacon, Telex, Eccles
LONDON OFFICE: SELINAS LANE, DAGENHAM ESSEX. PHONE: DOMINION 2277/8/9
TGA TRI

HIGH-VACUUM DISTILLED

MERCURY

FOR THE HIGHEST PURITY
4 DISTINCT GRADES AVAILABLE

★ **SINGLE VACUUM DISTILLED**

★ **DOUBLE VACUUM DISTILLED**

★ **TRIPLE VACUUM DISTILLED**

★ **POLAROGRAPHICALLY PURE**

Write or Telephone for leaflet

D. & J. M. ATKINSON LTD.

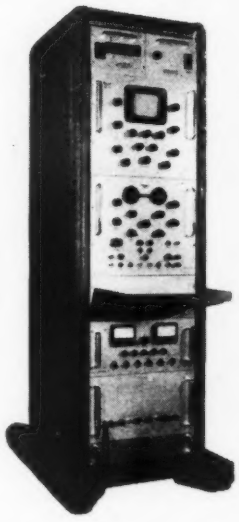
SUPPLIERS AND REFINERS OF MERCURY

214 BISHOPSGATE, LONDON, E.C.2

TELEPHONE: BIShopsgate 9026

Tick No 113 on reply card for further details

MARSHALL



PULSE HEIGHT ANALYSER
TYPE H.S.100

★ Torsional delay line data storage with computer reliability

★ Resolution constant or proportional to amplitude

★ Background subtraction

★ Analysis of pulses of either sign from 1 mV to 50 V

★ Binary and decimal storage

★ Both digital and analogue display

★ Analogue readout and automatic printout using either adding machine or electric typewriter

★ Storage capacity 2400 digits

★ High stability and linearity

★ Built-in precision test pulse generator

★ Total count scaler and accurate live time integrator both of which are available for use as separate units

MARSHALL
TWIN-CHANNEL PULSE GENERATOR MODEL T·P·G·100

Designed as a universal instrument for the development and general testing of electronic equipment. Extreme flexibility in use is achieved by virtue of the complete independence of the two channels apart from a common repetition frequency. The output pulses are fast-rising, of clean waveform, and at low impedance level.

In addition to the facilities normally offered in a pulse generator, precise measurements of the resolution time of coincidence circuits, triggering characteristics of discriminators, and the overload performance of pulse amplifiers are readily made.

A pre-pulse is provided for the purpose of triggering auxiliary apparatus.

The "A" and "B" channel output pulses are independently variable in amplitude, duration, risetime, delay relative to the pre-pulse and polarity.

Pulses from the two channels may be additively mixed if desired so that they appear at a single terminal.

FOR COMPLETE DATA WRITE TO:

MARSHALL OF CAMBRIDGE ELECTRONICS LIMITED

THE AERODROME, CAMBRIDGE, ENGLAND

Tick No 114 on reply card for further details

IF process plant in stainless or alloy steels is your problem, our technical representative will be pleased to discuss it with you. Ring the people who spend their working life (and a great deal of their private life) thinking and planning in STAINLESS STEEL.

BURNETT & ROLFE LTD.

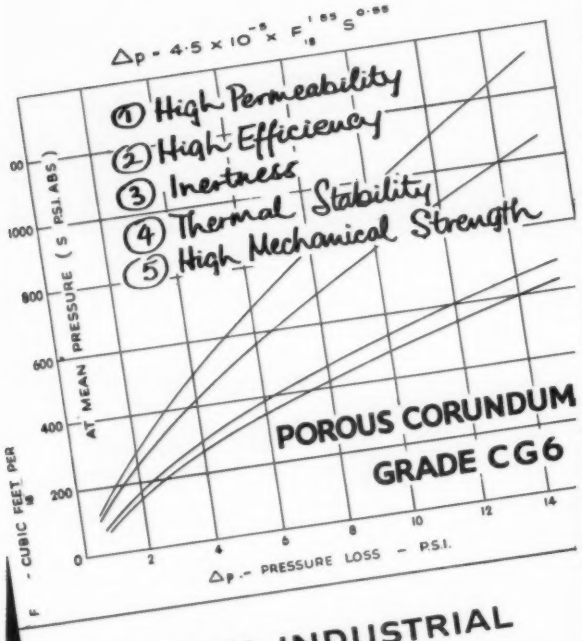
THE ESPLANADE, ROCHESTER, KENT

TEL: CHATHAM 41766

NORTHERN OFFICE: 32 DEANSGATE, MANCHESTER
TEL: BLACKFRIARS 9084

Tick **No 115** on reply card for further details

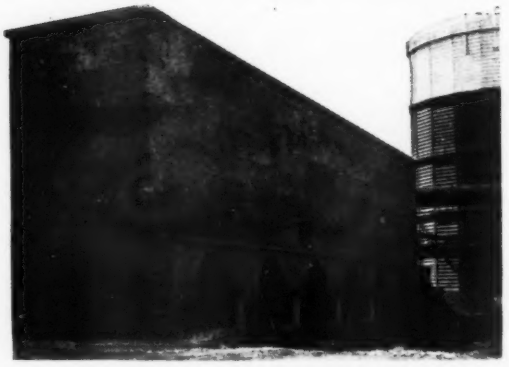
For the Cleaning of Gases


Δp - 4·5 × 10⁻⁵ × F^1·85 / S^0·85
① High Permeability
② High Efficiency
③ Inertness
④ Thermal Stability
⑤ High Mechanical Strength
POROUS CORUNDUM
GRADE CG6
AT MEAN PRESSURE (S PSI ABS)
F - CUBIC FEET PER
Δp :- PRESSURE LOSS - P.S.I.

DOULTON INDUSTRIAL PORCELAINS LIMITED

ROYAL DOULTON POTTERIES
WILNECOTE · TAMWORTH · STAFFS

Tick **No 116** on reply card for further details



PREMIER

THE FIRST NAME AND LAST WORD IN

COOLING TOWERS

WE DESIGN THE PLANTS
WE MANUFACTURE OUR OWN PRODUCTS
WE ERECT THE PLANT
WE GUARANTEE THE PERFORMANCE

Our after sales service and advice are always at your disposal

THE PREMIER COOLER AND ENGINEERING CO., LTD.
Shalford, near Guildford, Surrey

Tick **No 117** on reply card for further details

Heavy aggregates for shielding

BARYTES
ILMENITE
IRON SHOT

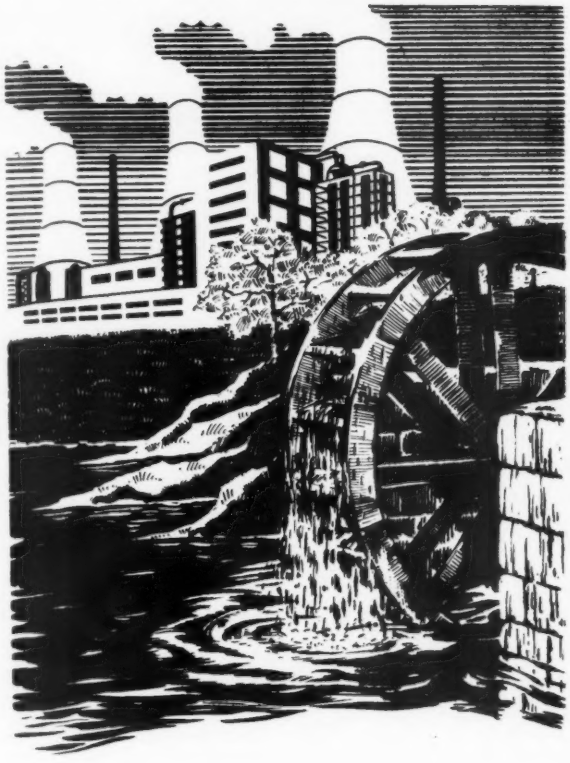
HOME AND EXPORT

UNITED CHEMICALS (London) LIMITED

147 Victoria Street, London, S.W.1

Cables : UNIC Tel.: TATe Gallery 9121

Tick **No 118** on reply card for further details



WATER

is still in the foreground...

However revolutionary the methods of producing power may become, water is still all-important; and the need to give complete and lasting internal protection to water tanks in modern plants remains paramount.

With a reputation consolidated over 30 years of successful use

BITOTES Solution and Enamel

prevents interior corrosion of all steel and concrete water containers and conduits. BITOTES cannot crack or peel and is tasteless and odourless when dry. It is fully approved for Fresh Water, Drinking Water, Demineralised Water, etc.

May we send you details

BITULAC LIMITED

(PAINTS DIVISION)

Collingwood Buildings, Newcastle upon Tyne, 1.

London Office: 189/190 Temple Chambers, Temple Avenue, London, E.C.4

Tick **No 119** on reply card for further details

A NEW LIGHT ON INDUSTRY

Seeing industry through the eye of camera and projector, Turners operators bring a new light and a fresh viewpoint to methods of staff recruitment, public relations, training, publicity and selling. All respond to the knowledge and experience that highly skilled operators put into...

TURNERS

FILM PRODUCTIONS

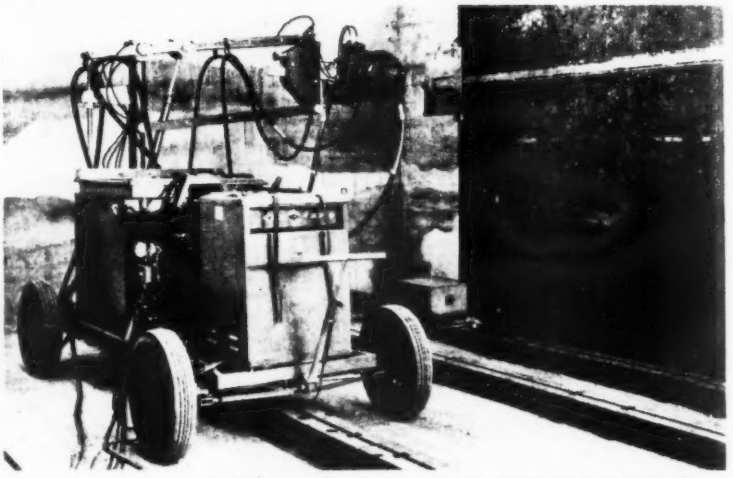
Profit by Turners experience of industrial filming and photography. Write, call, or phone.

Camera House, Fink Lane, Newcastle upon Tyne, 1. Telephone: Newcastle 2-5381.

Tick **No 120** on reply card for further details

INDUSTRIAL X-RAY EQUIPMENT

Where Mobility is essential



400 KV

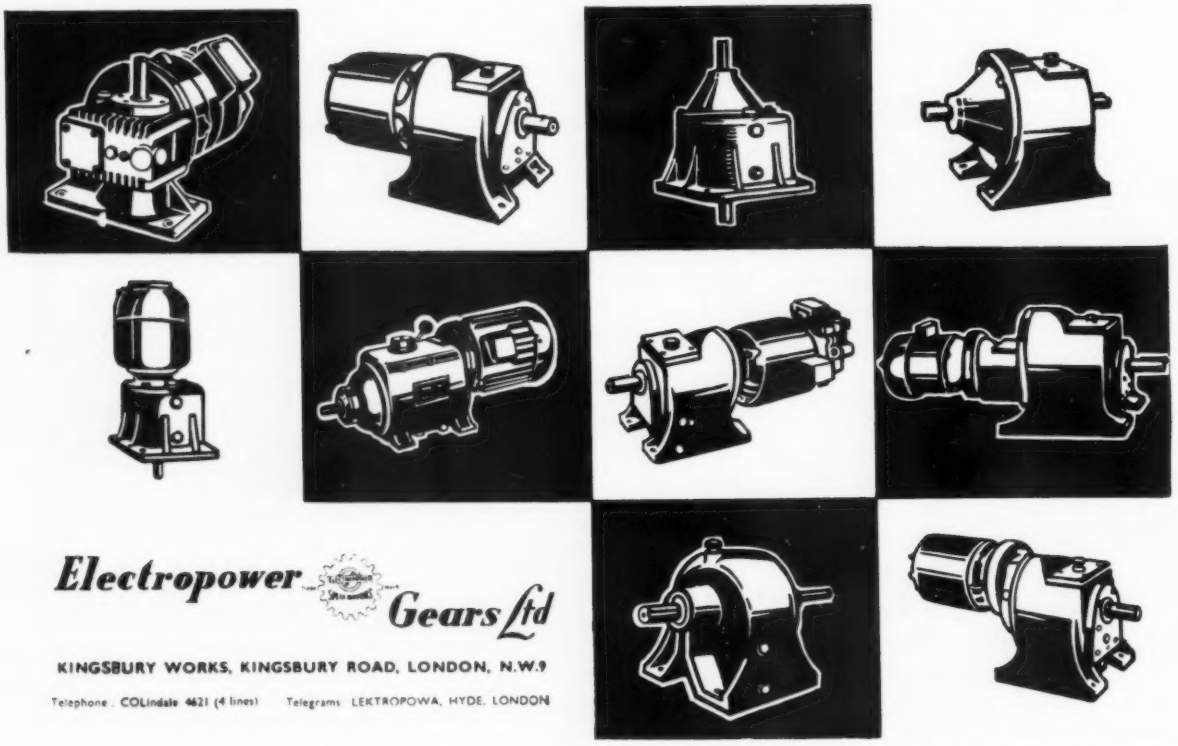
Photograph by kind permission of Messrs. International Combustion Limited.

This equipment was chosen by Messrs. International Combustion Limited, of Derby, for the radiography of large steel plates in their works. The Hydraulic tube mounting gives a wide range of coverage and the high output of the unit gives really short exposure times.

PANTAK LIMITED

VALE ROAD, WINDSOR, BERKS. Telephone: WINDSOR 3225-6

A VERY LARGE RANGE TO CHOOSE FROM 1/10-300h.p.



Electropower Gears Ltd

KINGSBURY WORKS, KINGSBURY ROAD, LONDON, N.W.9

Telephone: COLindale 4621 (4 lines) Telegrams: LEKTROPOWA, HYDE, LONDON

Tick **No 121** on reply card for further details

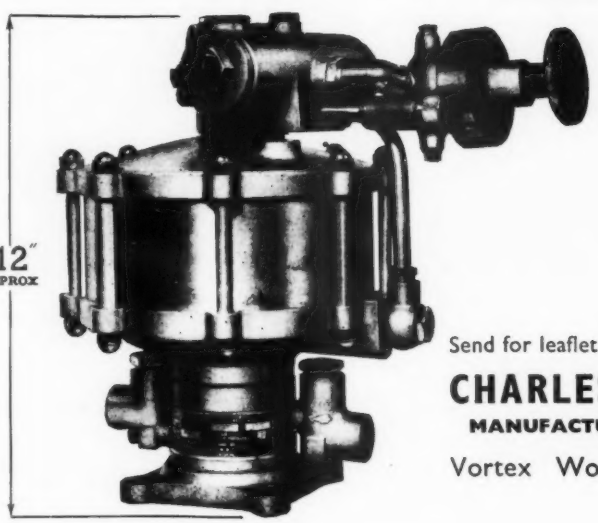
Tick **No 122** on reply card for further details

If you have compressed air . . .
you can have HYDRAULIC POWER

from 62 to 22,500 p.s.i.

economically - reliably - compactly

with the **AIRHYDRO POWER UNIT**



It will operate presses, hydraulic jacks, hydraulically loaded rolls and other equipment requiring hydraulic power, working from any compressed air line of 5 to 100 p.s.i. Gives a high hydraulic output with no trouble and negligible maintenance. No air consumption when maintaining static pressure. Nine models give pressure range from 62 to 22,500 p.s.i.

Manufactured by the makers of the 'AIRHYDROPUMP'

Send for leaflet A.P.U.2/11 complete with output graphs

CHARLES S. MADAN & CO. LTD.

MANUFACTURERS OF THE WORLD FAMOUS 'AIRHYDROPUMP'

Vortex Works, Atlantic Street, Altrincham, Cheshire

Tel: Altrincham 2702 (3 lines) CM11

industries atomiques

International review for the peaceful application of nuclear energy

INDUSTRIES ATOMIQUES
is the only international technical and industrial review printed in French, which specialises entirely in nuclear and related subjects.

INDUSTRIES ATOMIQUES is read by industrialists, engineers, technicians and chemists, heads of technical firms and by all those engaged in the world of science. In short, it is intended expressly for all specialists interested in research and in its practical realisation.

In view of its international character, **INDUSTRIES ATOMIQUES** is read and appreciated in countries all over the world.

Up to date, more than 200 authors, all specialists, have honoured this review with their collaboration, and have contributed **previously unpublished** articles of high scientific value, abundantly illustrated.

INDUSTRIES ATOMIQUES is a source of precise documentation, constantly being brought up to date. The international information and the list of suppliers to the atomic industries printed in its pages will be found invaluable.

Annual Subscription

12 numbers per year	
French francs	4,150
Belgian francs	510
Swiss francs	35
U.S. dollars	8.50
Pounds sterling	3

Industries Atomiques Subscription form

Subscriptions can be paid in the currency of the country at any European post office.

We desire _____ annual subscriptions, starting from _____, to be sent to (surname, Christian names, or firm's name, and address) _____

Method of payment _____ Date and signature :

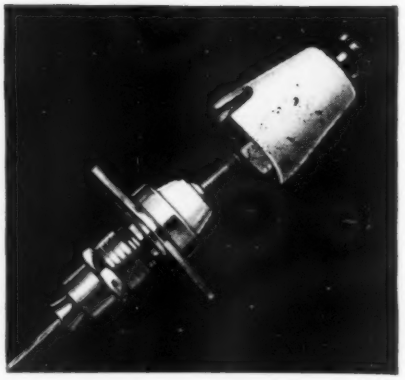
(This form should be returned in a stamped and addressed envelope to NUCLEAR POWER, 3 Percy Street, London, W1.)

INSULATION AND STRENGTH

material answer to design problems

Sintox—an alumina ceramic of exceptional insulation characteristics—is superior in tension, compression and cross-breaking. In small assemblies it can be an insulator *and* a structural support.

Sintox also stands elevated temperatures with little change in its properties, has high thermal conductivity and superior corrosion resistance and—for nuclear application—low neutron capture cross-section.



Graviner Aircraft Fire Detection Systems incorporate SINTOX ceramic insulators, which retain their mechanical strength unimpaired throughout the widely fluctuat'ng temperature range encountered.

Sintox Technical Advisory Service

This service is freely available without obligation to those requiring technical advice on the application of Sintox Industrial Ceramics. Please write for booklet or any information required enclosing blueprint if available.

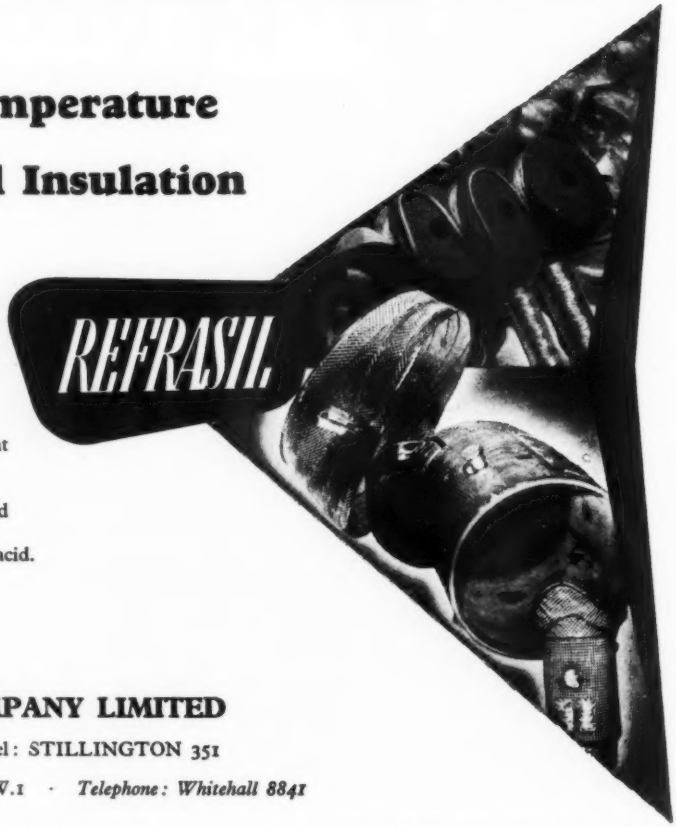
SINTOX engineering ceramics

SINTOX IS MANUFACTURED BY **LODGE PLUGS LTD., RUGBY**

Lightweight **High Temperature**

Thermal & Electrical Insulation

REFRASIL is a unique material—
a vitreous silica fibre, light in weight,
of very fine diameter, and
capable of withstanding continuously
temperatures up to 1,000°C
(and even higher for short periods).
REFRASIL has outstanding thermal
insulating characteristics at high
temperatures, as well as being an excellent
high temperature electrical insulator.
It is available as batt, cloth, tape,
sleeving, bulk fibre, yarn or metal-covered
blankets. It is highly-resistant to
thermal shock and chemical attack from acid.



For further details about Refrasil please write to—

THE BRITISH REFRASIL COMPANY LIMITED

STILLINGTON, COUNTY DURHAM Tel: STILLINGTON 351

London Office: 5 Petty France, Westminster, S.W.1 · *Telephone: Whitehall 8841*

CLASSIFIED ADVERTISEMENTS

DISPLAY ANNOUNCEMENT RATES :— 1 insertion 40/- per single col. inch
6 insertions 38/- per single col. inch
12 insertions 36/- per single col. inch

LINEAGE ANNOUNCEMENT RATES :— 4/- per line. 5% discount 6 insertions, 10% discount 12 insertions

BOX Nos. :— 1/- extra will be charged

COPY DATE :— Advertisements must be received not later than 14th July for August issue

SITUATIONS VACANT

THE UNIVERSITY OF MANCHESTER

Applications are invited for the post of LECTURER IN ENGINEERING (NUCLEAR). Candidates should be graduates in engineering or physics : experience of experimental reactor physics or heat transfer would be an advantage. The successful candidate will take part in teaching and research work in the Nuclear Engineering Laboratory. University regulations permit teaching staff to read for the degrees of M.Sc. and Ph.D. Applications will also be considered from engineers and physicists who would be interested in a temporary appointment of two or more years. The salary scale is £900 to £1,650 per annum. Membership of the F.S.S.U. and Children's Allowance Scheme. Initial salary according to qualifications and experience. Applications should be sent not later than July 18th, 1959 to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained. Applications by airmail (no forms) will be considered from overseas candidates.

WELDING - A Chief Site Welding Engineer is required for a nuclear power construction project. He must have (1) sound practical experience of heavy, site welded, steel fabrications, (2) ability to establish and maintain the highest possible welding quality, and (3) an energetic disposition, able to get on well with people and to organise efficiently. An attractive salary will be paid to the right man.

All replies will be treated in strict confidence by a welding consultant who is advising on this appointment and should be in writing to Box No. NP 205

Applications are invited for posts as

PROFESSIONAL ENGINEERS and PHYSICISTS

in a research team carrying out technical and design work on nuclear propelled vessels. The location of the work has not yet been finally decided, but successful applicants must be prepared to work for a time at Harwell, and probably other places in England.

Applicants should hold an appropriate Honours Degree. Drawing Office and practical experience will be an advantage. Salaries will be appropriate to the duties performed and there is a contributory Pension and Life Assurance Scheme.

All applications will be treated in confidence and should be addressed to : The Manager,

MARINE PROPULSION, RESEARCH AND DEVELOPMENT,
VICKERS-ARMSTRONGS (ENGINEERS) LTD.,
NAVAL CONSTRUCTION WORKS, BARROW-IN-FURNESS, LANCASHIRE

EDUCATIONAL

U.K.A.E.A.

HARWELL REACTOR SCHOOL

Standard Course No. 19

The next standard course will be held from 31st August to 18th December, 1959, inclusive. The fee for the course is £250 exclusive of accommodation.

SENIOR TECHNICAL EXECUTIVES' COURSE NO. 9

The course will be held from 21st September to 1st October, 1959, inclusive. The fee for the course is 50 guineas exclusive of accommodation.

Application forms and details of both courses can be obtained from :-

The Principal,
Reactor School,
Atomic Energy
Research Establishment,
Harwell, Didcot, Berkshire.

SYMPOSIUM

The French Society of Metallurgy is organising, with the full co-operation of the French Atomic Energy Authority, an INTERNATIONAL SYMPOSIUM ON THE METALLURGY OF PLUTONIUM which is to take place at Grenoble on the 19th to 22nd April 1960. The subjects to be covered will range from the physics of plutonium metallurgy to the technology of fissile materials.

If you wish to attend this Symposium or present a paper, please write to :

Société Française de Métallurgie
25 rue de Clichy, Paris - or to -
Monsieur E. Grison
Centre d'Etudes Nucleaires de
Fontenay-aux-Roses (Seine)

TRADE SERVICES

ALPHAMIN LIMITED - A complete design and fabrication service available for all types of aluminium and steel fabrication including welding by Argonarc process. We have considerable design experience and would welcome your enquiries. 4 Dunston Street, Kingsland Road, London, E.8. Phone CLIssold 4161.

HOUSES FOR SALE

NEW SUPERIOR-DESIGNED DETACHED AND SEMI-DETACHED HOUSES

CULCHETH

NORTH-WEST ENGLAND (NR. RISLEY) - planned to give generous accommodation and ease of running ; these are modern labour-saving houses with garage. Prices from £2175 with £13 G.R. inclusive of all road charges.

Main line Direct to Trafford Park and Manchester.

E.E. COLEMAN, LTD
(Builders of Fine Houses)

WAVERLEY ROAD, SALE.

TEL. SALE 2201

SUPPLIES

MANOMETERS in solid Perspex (portable - unspillable - light)

Also CO-test tubes and Minchin Double Aspirator for reliable quick estimation of CO traces in air.

COMBUSTION INSTRUMENTS
61, Belsize Lane, London, N.W.3

BELGRAVE (MERCURY) LIMITED

REFINERS and SUPPLIERS of all grades of Mercury to hospitals, research laboratories, the engineering and electrical industries etc.
REGULAR BUYERS of dirty Mercury in any quantity or condition.
5, Belgrave Gardens, LONDON, N.W.8. Tel.: MAI 7513.

METALLURGISTS

Foundry Consultants, Analytical Chemists, Heat-treatment Specialists, Testing Engineers

KEIGHLEY LABORATORIES LTD

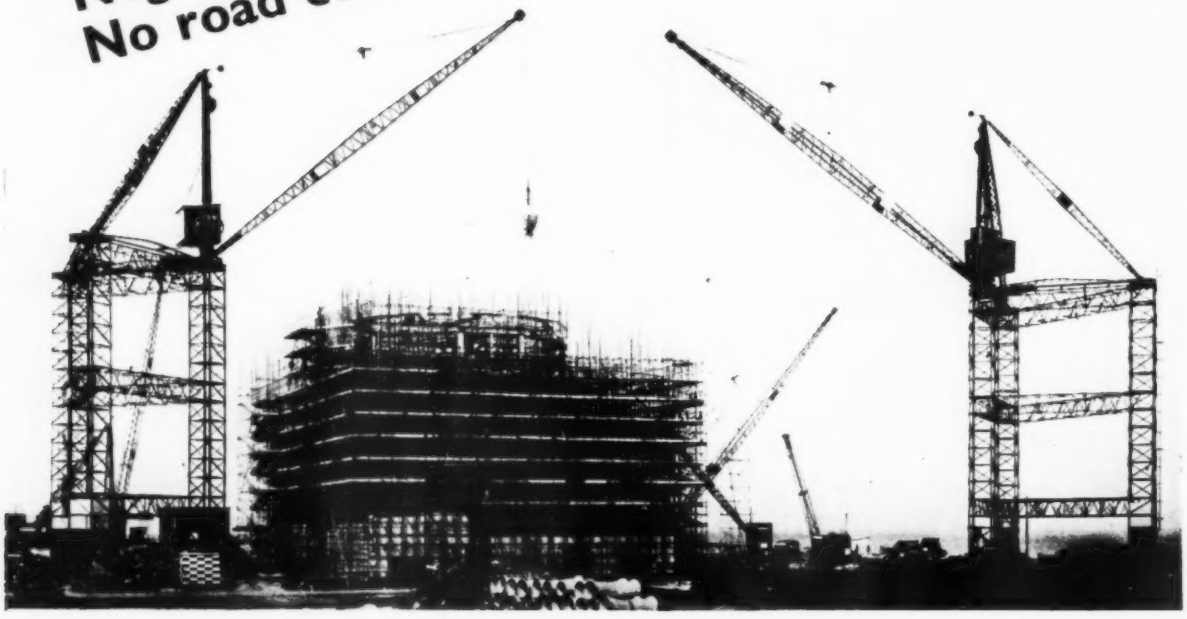
Croft House, South Street, Keighley, Yorks. Tel. Keighley 3744(2 lines)

R. & J. PARK LTD
Dominion Works, Chiswick
England

*

Export packers, shippers and forwarding agents. Specialists in packing heavy machinery.

★ Lower first cost
★ Much lower running costs
Negligible maintenance costs
No road costs



and a very high degree of efficiency and reliability

BUTTERS DERRICKS

★ **These are some advantages of Butters Derricks in comparison with cranes of other types and similar performance.**

And, of course, operational speed is high, with complete safety and ease of control. Supplied in sizes, power and jib length to requirements.

At the nuclear power stations

The picture shows two standard 10-ton travelling derricks with jibs 120 ft. long, on 80-ft. towers with self-travelling bogies.

Supplied to Messrs. Taylor Woodrow Construction Ltd. for use in building Hinkley Point Power Station, these cranes were delivered and erected by us at the site and handed over ready for operation.

BUTTERS CRANES served or are serving at CALDER HALL, CHAPELCROSS, DOUNREAY, HINKLEY POINT, BERKELEY, BRADWELL and HUNTERSTON

BUTTERS BROS. & CO. LTD., Maclellan Street, Glasgow, S.1
LONDON: THE CRANE WORKS, LONG LANE, HILLINGDON, MIDDLESEX
AND AT BIRMINGHAM & NEWCASTLE

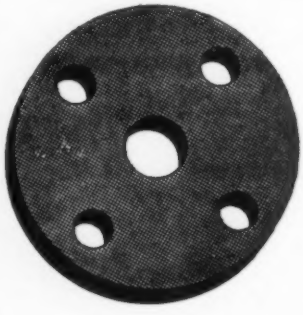
handling
Mechanical handling systems engineered to specific needs are a Teleflex speciality. Overhead installations incorporate the unique Teleflex Dual-Directional chain and a system can perform the functions of weighing, sampling, elevating, distributing, batching, etc. Automatic electronic control may be employed if required.
and
control
Teleflex industrial Remote Controls comprise the simplest and most economical means of transmitting rotary or straight line motion to remotely positioned units. The system is readily adaptable to any requirement and comprises a positive-motion push-pull flexible cable within conduit. Among its applications are dampers, ventilators, switchgear, V.S. units, safety devices, valves, etc.
Full details and literature gladly sent on request
Teleflex
TELEFLEX PRODUCTS LTD Remote Control Division BASILDON ESSEX
Telephone: BASILDON 2286l
Telegrams: PHONE BASILDON
Cables: TELEFLEX BASILDON

Tick **No 127** on reply card for further details

ADVERTISERS IN THIS ISSUE

Accles & Pollock Ltd	22
Albright & Wilson (Mfg.) Ltd	99
Atlas Steel Foundry & Eng. Co. Ltd, The	108
Amal Ltd	110
Anglo Swedish Electric Welding Co. Ltd	102
Appleby & Ireland Ltd	27
Armstrong Whitworth Aircraft Ltd, Sir W.G.	113
Atomics International	23
Atkinson Ltd, D. & J.M.	118
Automotive Products Co. Ltd	56
Autoset (Production) Ltd	100
Barytes Shielding Products Ltd	109
Bailey & Co. Ltd, Sir W.H.	118
Bettles & Sons Ltd	118
Beldam Asbestos Co. Ltd	104
Bitulac Ltd	121
Blackwell's	98
Boby & Co. Ltd, William	26
Boving & Co. Ltd	6
Brady & Co. Ltd, G.	35
Bristol Siddeley Engines Ltd (Beaver Hall)	28
British Paints Ltd	29
British Siddeley Engines Ltd (Gas bearings)	46
British Ermeto Corp. Ltd	38
British Refrasil Co. Ltd, The	124
Burnley Aircraft Co. Ltd	52
Burnett & Rolfe Ltd	119
Burgess Products Co. Ltd	39
Butters Bros. & Co. Ltd	126
Cashmore Ltd, John	50
Clay Cross (Iron & Foundries) Ltd	47
Comercroft Ltd	108
Consett Iron Co. Ltd	42
Cox & Danks Ltd	100
Darham Industries (London) Ltd	105
Delaney Gallay Ltd	95
Doulton Industrial Porcelains Ltd	120
Ecko Electronics Ltd	93
Electropower Gears Ltd	122
Erhard, Johannes	20
Evans & Son (Portsmouth) Ltd, J.	40
English Electric - Babcock & Wilcox - Taylor Woodrow	53
Fairey Eng. Ltd	41
Fielding & Platt Ltd	16
Firth & John Brown Ltd, Thos.	58
Firth– Derihon Stampings Ltd, The	14
Flight Refuelling Ltd	97
Gem Power Brushes Ltd	107
General Electric Co. Ltd, The	62
Graviner Mfg. Co. Ltd	107
Grey & Marten Ltd	111
Harvey & Co (London) Ltd, G.A.	21
Head Wrightson Processes Ltd	24
Heather Filters Ltd	114
Hilger & Watts Ltd	112
Holland Eng. Co. Ltd, The B.A	105
Howden & Co. Ltd, James	Cover 3
Imhof Ltd, Alfred	11
Imperial Chemical Industries Ltd (Plastics Division)	31
Industrial Descaling Tools Ltd	116
Industries Atomiques	123
Kennedy & Co. Ltd, Allan	48
Lewis & Co. Ltd, H.K.	98
Lloyd & Ross Ltd	117
Lodge Plugs Ltd	124
Lyons Ltd, Claude	101
M & C Nuclear Inc	89
Madan & Co. Ltd, Charles	123
Magnesium Elektron Ltd	111
Magnetic Valve Co. Ltd, The	18
Mallinson & Sons Ltd, William	104
Marshall of Cambridge Electronics Ltd	119
Marston Excelsior Ltd	57
Metalectric Furnaces Ltd	110
Metropolitan - Vickers Electrical Co. Ltd	7
Milne & Co. Ltd, C.S.	106
Mollart Eng Co. Ltd	61
Morris Ltd, H.O.	34
Mountford (Birmingham) Ltd, Frederick	115
Mullard Ltd (X-ray div.)	43
Murex Welding Processes Ltd	25
Nash & Thompson Ltd	8
Newalls Insulation Co Ltd	33
Necker Water Softening Co. Ltd	115
Palatine Tool & Eng. Co. Ltd	103
Pantak Ltd	122
Pascall Eng. Co. Ltd, The	116
Premier Cooler & Eng. Co. Ltd, The	120
Pye Ltd	12
Research & Control Instruments Ltd	3, 103, 113
Richardsons, Westgarth & Co Ltd	45
Rio Tinto Management Services (UK) Ltd	64
Rocol Ltd	2
Rotameter Mfg. Co. Ltd	101
Sandall Precision Co. Ltd	118
Sankey-Sheldon Ltd	36, 37
Savage & Parsons Ltd	59
Screw Machine Products Ltd	116
Shell-Mex & B.P. Ltd	4, 5
Simmonds Ltd, L.E.	109
Simplifix Couplings Ltd	32
Skinningrove Iron Co. Ltd	51
Solartron Electronic Group Ltd, The	Cover 4
Soole & Son Ltd	116
Steels Engineering Installations Ltd	30
Stainless Steel Profile Cutters Ltd	128
Super Oil Seals & Gaskets Ltd	10
Superheater Co. Ltd, The	19
Swiftplan Ltd	13
Taylor Rustless Fittings Co. Ltd, The	9
Taylor Stainless Metals Ltd	102
Taylor, Taylor & Hobson	117
Teddington Aircraft Controls Ltd	91
Teleflex Products Ltd	127
Tees Side Bridge & Eng. Works Ltd	112
Texas Instruments Ltd	Cover 2
Turners Film Productions	121
Union Carbide Corp	17
United Chemicals (London) Ltd	120
Vacu-Blast Ltd	114
Vokes Ltd	49
Wakefield Dick Industrial Oils Ltd	60
Wandleside Cable Works Ltd	44
Western Detail Manufacturers Ltd	15
Westool Ltd	54, 55
Williams & James (Engineers) Ltd	106

Tick **No 128** on reply card for further details



STAINLESS TUBES & FLANGES

We offer in approved grades of Stainless Steel

★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES
★ SOLID DRAWN TUBES—FABRICATED PIPES
★ ROUND and HEXAGON BAR
★ PROFILES CUT TO ANY THICKNESS OR SIZE
★ CASTINGS TO CUSTOMERS SPECIFICATION

Keen Prices — Prompt Delivery

Send enquiries to Dept. N.P.

STAINLESS STEEL PROFILE CUTTERS LTD.

Farfac Works, Kings Grove, MAIDENHEAD. *'phone* 1522/23.

Published by and Printed for ROWSE MUIR PUBLICATIONS LTD., 3 Percy Street, London, W.1. England

Tick **No 206** on reply card for further deta

The original WINDSCALE

plant, with the first full-scale atomic piles in this country had 16 high-efficiency blowers of great capacity, each absorbing 2,500 h.p. These were supplied by

HOWDEN

For the new advanced gas-cooled reactor AT WINDSCALE

Howden have been chosen to supply four main CO_2 circulators having the following features:—

(1) Inlet Vane Control giving stable operation over full operating range.
(2) High-efficiency aerofoil-bladed radial-flow Impeller and Diffuser.
(3) Oil-bath Bearings.
(4) 1570 h.p. constant-speed A.C. Motor
(by Laurence Scott & Electro Motors Ltd.).
(5) Special Cooling Arrangements.
(6) Entire assembly enclosed in Pressure Bell.

This novel arrangement of circulator requires aerodynamic, heat transfer, and mechanical design of extremely high quality.

A factor influencing the selection of Howden's for this important contract is their extensive experience in all these aspects of design and of the manufacturing problems involved.

JAMES HOWDEN AND COMPANY LIMITED
195 SCOTLAND STREET, GLASGOW, C.5, and 15 GROSVENOR PLACE, LONDON, S.W1.

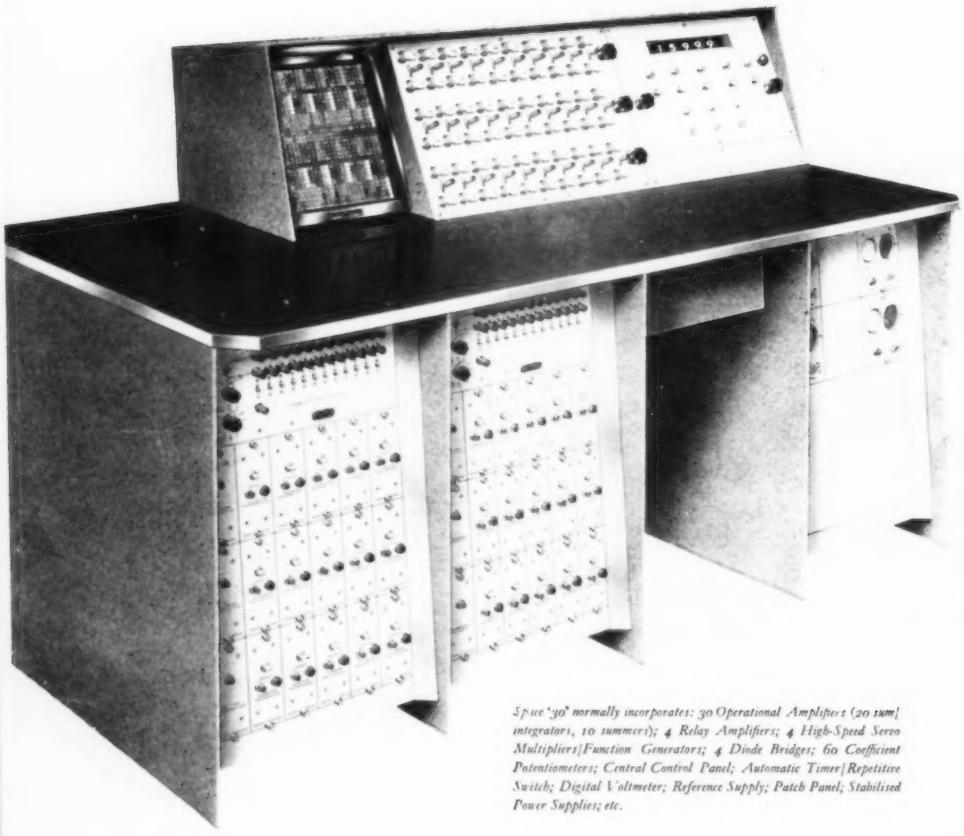
HOWDEN

No 207 on reply card for further details

SOLARTRON

Space '30' Analogue Computer

foremost in flexibility



Space '30' normally incorporates: 30 Operational Amplifiers (20 sum/integrators, 10 summers); 4 Relay Amplifiers; 4 High-Speed Servo Multipliers/Function Generators; 4 Diode Bridges; 60 Coefficient Potentiometers; Central Control Panel; Automatic Timer/Repetitive Switch; Digital Voltmeter; Reference Supply; Patch Panel; Stabilised Power Supplies; etc.

Space '30' represents a significant advance in analogue computer design, combining high accuracy with a high work load factor, plus comprehensive control and programming facilities in a single unit of outstanding operational flexibility.

Design optimisation has resulted in a computer with problem handling capacity equivalent to the usual 40 Amplifier or larger machine. A central, detachable problem board, digital voltmeter programming and other special control features which provide full problem-check facilities, automatic decade scaling, double computation and allowance for external control are incorporated.

Space '30' is particularly useful as a research or training simulator, especially in nuclear reactor and automatic control systems work, or wherever large dynamic range capabilities are required.

Optimised Design—Maximum Capacity for Minimum Outlay

Central Patching and Programming by Digital Voltmeter

High Accuracy Components, Linear and Non-Linear Units

'Plug-in' Expansion Facilities

Maximum Ease of Operation and Accessibility with Aesthetic Appeal

Write today for full details

The Solartron Electronic Group Ltd. Thames Ditton Surrey

Tel: **EMBerbrook 5522** *Cables:* **Solartron, Thames Ditton.** ***International Telex:*** **23842 Solartron T. Dit.**

mum
ay
ming
inear
and
ppeal
Dit.